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SOIL AND WATER CONSERVATION PROJECTS AND ACTIVITIES, A GUIDE FOR 4-H CLUB LEADERS.

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THIS PUBLICATION WAS PREPARED BY THE SOIL CONSERVATION SERVICE FOR USE WITH YOUTH GROUPS. VARIOUS ACTIVITIES AND PROJECTS ARE PRESENTED WHICH CAN BE USED TO DEVELOP CONCEPTS ABOUT SOIL AND WATER CONSERVATION. IN ORDER TO SIMPLIFY THE PROCESS OF DEMONSTRATING THESE ACTIVITIES, MANY OF THE CONCEPTS ARE PICTORIALLY ILLUSTRATED. THE ACTIVITIES INCLUDE--(1) MAKING SOIL ARTIFICIALLY, (2) COMPARING THE SIZE OF DIFFERENT TYPES OF SOIL PARTICLES, (3) HOW SOIL IS AFFECTED BY WATER, PLANTS, AND ORGANIC MATTER, (4) HOW A STREAM CARRIES SEDIMENT, (5) THE VALUE OF CONTOURING, (6) HOW FERTILIZER AFFECTS PLANT GROWTH, (7) HOW BIRDS HELP DESTROY INSECTS, (8) THE MANY USES OF WOOD, AND (9) BUILDING A MODEL CONSERVATION FARM. (ES)

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Soil and Water Conservation Projects and Activities

• A Guide for 4-H Club Leaders

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Soil Conservation Service and Federal Extension Service Cooperating

UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

How wisely our soil and water resources are managed and protected will be reflected in the wealth and the spirit of tomorrow's people. All of us have a share in the job to be done. Youth in 4–H Clubs have an important role in this job.

The Soil Conservation Service is responsible for the content of this publication which was prepared originally for use by other youth groups. Through cooperation with the Federal Extension Service the publication has been adapted and made available for use by 4–H Club leaders in developing sound concepts on conservation. The activities are suitable for individual or team demonstrations. Each is presented in two parts: How-to-do-it and interpretation.

Local situations may call for additional steps to make the projects or activities fit local needs. Many State publications can supplement this publication.

There are many opportunities for recognition of good conservation work by young people. 4–H leaders may get information from county extension agents about projects, activities, and recognitions.

Many organizations and leaders can help in this program. Farmers and ranchers who are practicing soil and water conservation on their land are well qualified to assist 4–H Club leaders. People who have served as officials of organizations concerned with conservation can help by sharing their experience. Many others have personal experience and knowledge which will supplement this guide. All can provide the stimulus that will inspire young people to be mindful of the need for conserving our Nation's natural resources.

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SOIL AND WATER CONSERVATION PROJECTS AND ACTIVITIES—A GUIDE FOR 4–H CLUB LEADERS

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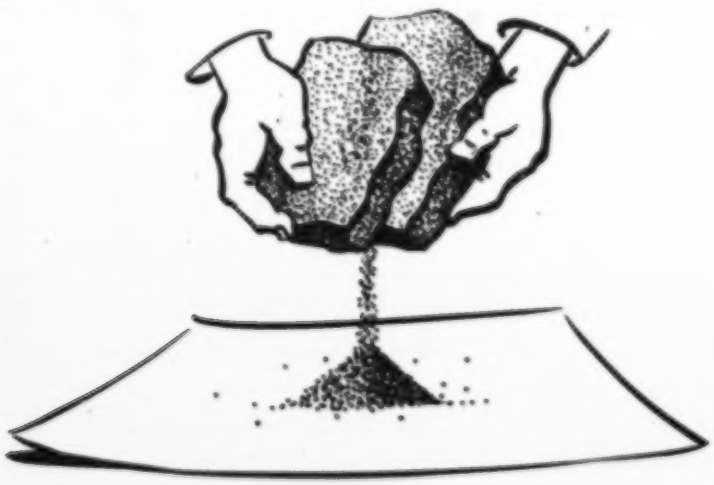
I. Make Some Soil Artificially

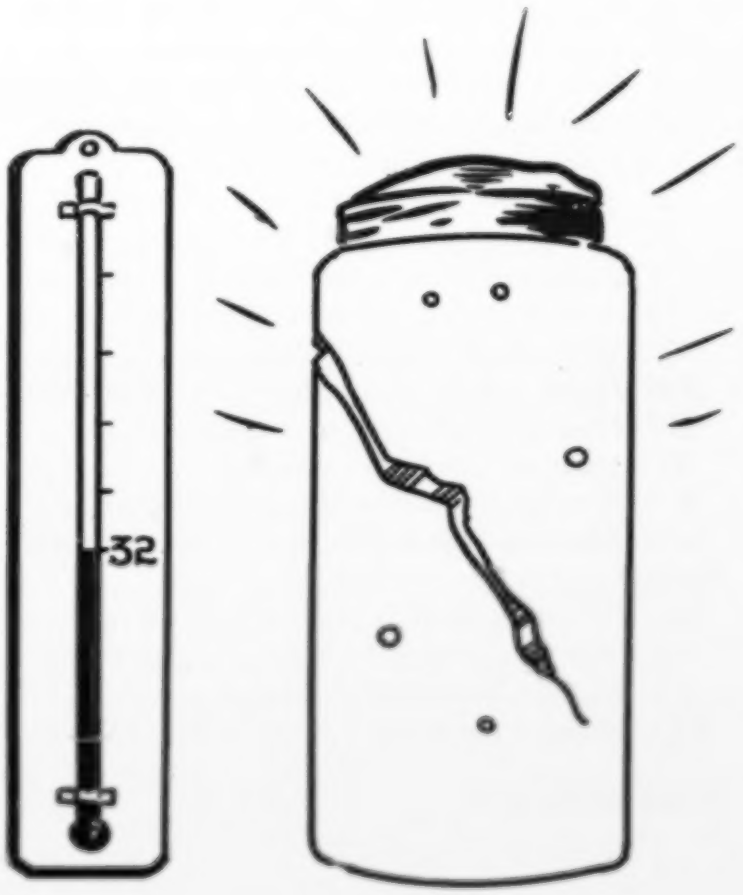
4–H Club boys and girls can show how some of the forces of nature break down rocks into soil material by several simple demonstrations:

1. Rub two pieces of limestone or fine sandstone together. If you do not have natural stone, pieces of building bricks or concrete will do. Notice how long it takes to rub off even a few fine particles.

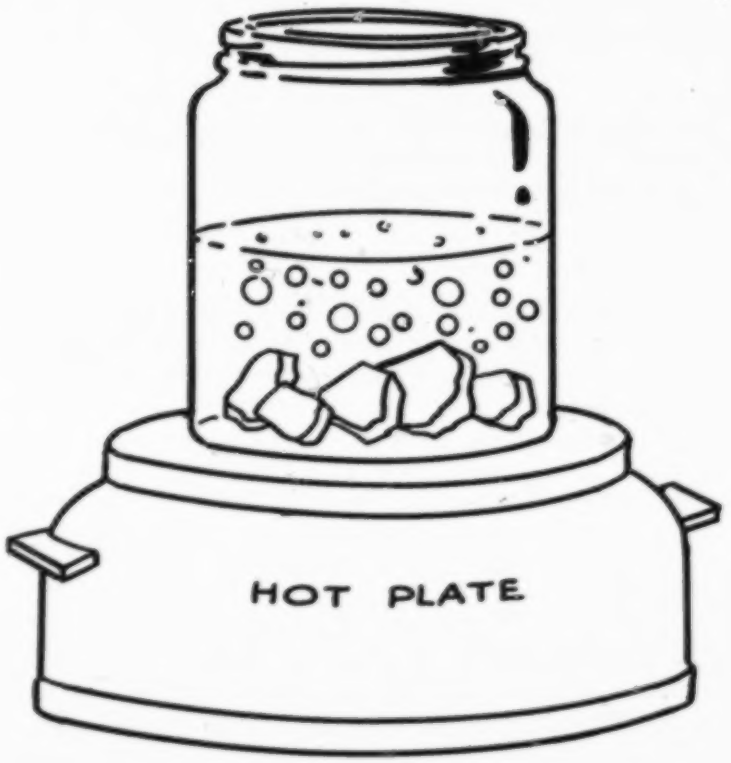


2. Heat a small piece of limestone over a flame or on a hot plate. Drop it quickly into a pan of ice water. The rock should break or crack as it contracts after its expansion by heating.

3. Fill a small discarded glass jar with water and cap it tightly. Let it freeze outdoors or in the freezing compartment of a refrigerator. Note what happens to the jar.



4. Put some small pieces of limestone in a little vinegar. Heat the vinegar on a hot plate or over a burner and notice how bubbles form on the pieces of stone. These bubbles are carbon dioxide gas made from carbon and oxygen released from the limestone by a chemical change in the rock caused by the acid in the vinegar. If you continued this process long enough, all the limestone would gradually break down.



soil as they are deposited in some flood plain or at the bottom of a lake.

When you put the limestone in the vinegar, you were duplicating in a small way what plants do. Plant roots take in oxygen from the soil air and give off carbon dioxide gas. This gas is one of the important end products in the decay of organic matter.

Carbon dioxide gas dissolves in the soil moisture, forming weak carbonic acid. This acid reacts just as the acetic acid in vinegar did with limestone rock and will decompose limestone and marble. The dissolving effect of this carbonated water is several times that of pure water. Since the lime in limestone is soluble, it gradually dissolves leaving only the other materials as soil. It takes 40 to 50 feet of limestone to make only a few inches of soil.

There are other physical and chemical factors that also aid in soil formation. For example, wind blows small rock particles against larger ones, wearing both down. As explained later, even plant and animal life play an important role in soil formation.

INTERPRETATION

Soil is formed from rocks very very slowly.

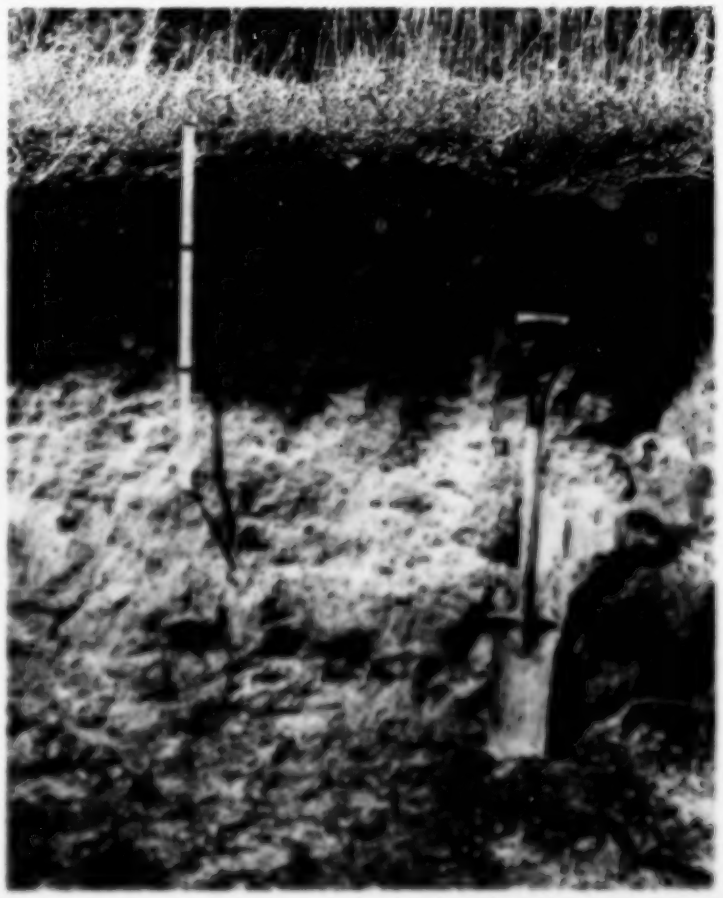
When you rub two rocks together, small particles rub off. It takes a long time to accumulate even a spoonful. When large sheets of ice (glaciers) moved over the land thousands of years ago, they ground rocks together, rubbing off tremendous quantities of rock particles of all sizes. Much of the north central United States is made up of soils that were formed from rocks carried by these glaciers.

Changes in temperature also help to make soil. The sun warms the rocks during the day. At night the rocks cool. The expansion and contraction chips off particles of rock just as you saw when you dropped the hot limestone into cold water.

Freezing water expands with tremendous force. Water that finds its way into cracks in the rocks freezes and breaks the rocks into smaller and smaller pieces.

Most of the soils we see today developed from rock material that was moved by water or wind either after this "weathering process" or while it was going on.

Soils are also formed as rocks are rolled along by streams. Note how smooth the pebbles are you see on beaches and along streams. They have been rubbed together until the rough parts are knocked off. These rubbed-off particles make up



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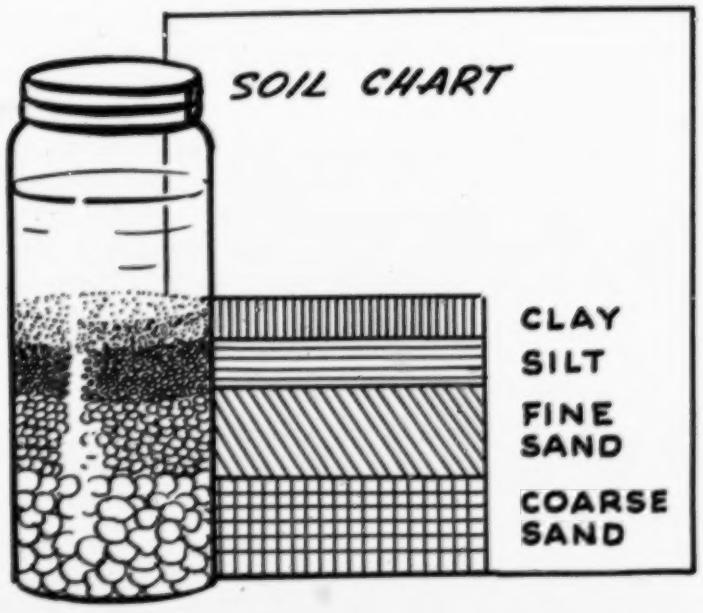
This dark, deep layer of topsoil is the product of centuries of weathering, accumulation of plant and animal remains, and the work of many living organisms. The less fertile subsoil, which is lighter in color, has little or no organic matter.

II. Are All Soil Particles the Same Size?

Fill a fruit jar about two-thirds full of water. Pour in soil until the jar is almost full. Replace the cover or put one hand tightly over the top of the jar and shake it vigorously. Then put the jar on the table and let the soil settle. Allow plenty of time because the very small particles will be slow in settling.

Then hold a card or heavy piece of paper against the side of the jar and draw a diagram showing the different layers. Label each layer (clay, silt, sand).



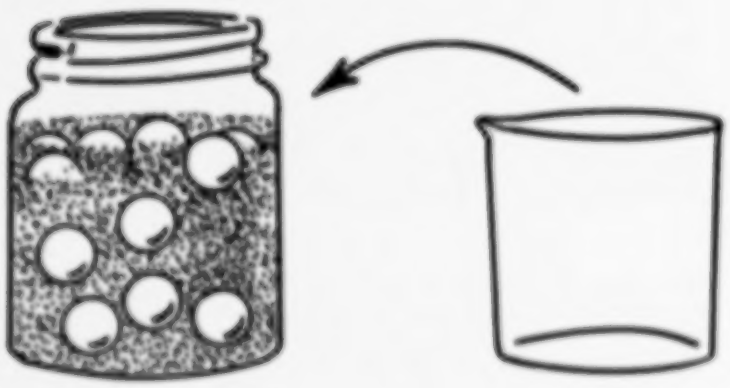
Do this with several soils taken from different places and compare the diagrams or compare the jars directly.

To demonstrate that coarse soils have pore spaces that can be filled with finer soils, try the following:

You will need a half-pint fruit jar, some marbles, and some sand. Put the sand in a measuring glass so that you can check how much you use.

Fill the fruit jar about two-thirds full of marbles. Then add sand. Tap the jar on the table a few times as you add the sand to be sure that all the pores are filled. Stop when the sand completely covers the marbles.

Check how much sand you used.



INTERPRETATION

Soil particles vary greatly in size. The largest particles settle to the bottom first. The fine particles settle slowly; some, in fact, are suspended indefinitely.

Soil scientists classify soil particles into sand, silt, and clay. Starting with the finest, clay particles are smaller than 0.002 millimeters in diameter. Some are so small that ordinary microscopes do not show them. Silt particles are from 0.002 to 0.05 millimeters in diameter. Sand ranges from 0.05 to 2.0 millimeters. Particles larger than 2.0 millimeters are called gravel or stones.

Most soils, as found in nature, contain a mixture of sand, silt, and clay in different proportions.

Size of soil particles is important. The amount of open space between the particles has a lot to do with how easily water moves through a soil and how much water it will hold.

Too much clay, in proportion to silt and sand, causes a soil to take in water very slowly. Such a soil also gives up its water to plants slowly. These soils are sticky when wet.

Loam and silt loam refer to soils that have a favorable proportion of sand, silt, and clay. A silt loam, for example, contains no more than 50 percent sand nor more than 27 percent clay. The rest, naturally, is silt.

Size of soil particles is important for other reasons, too. It affects the ease of working the soil, what crops can be grown, and the efficiency of certain fertilizers.

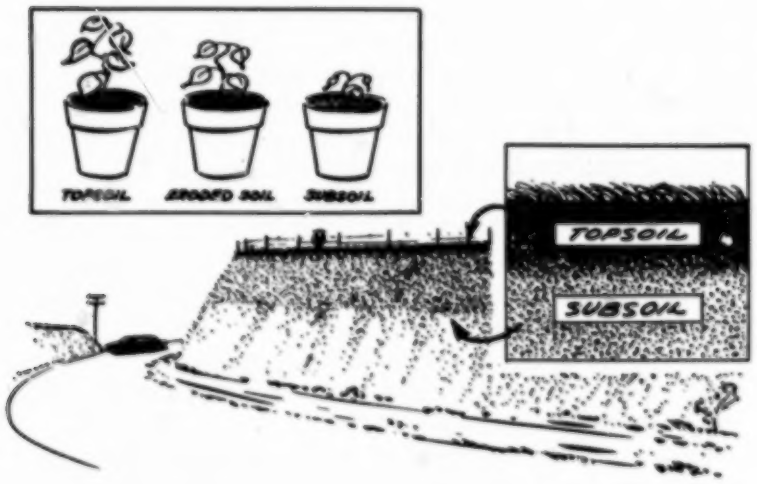
The marbles-and-sand demonstration shows that the pore space is larger in coarse soils and that the spaces may be filled partly with finer soil particles. This makes a more dense soil.

Sandy soils that have no fine clay or silt particles filling the pore space cannot hold as much moisture since there is less *surface area* for the water to cling to and the pores are so large that the weight of the water causes much of it to run down and out of the soil. For this reason, medium and coarse sandy soils low in clay, are known as droughty soils—crops cannot live long in them without very frequent rains.

When fine soil particles fill the large pore spaces, the soil can hold more water for plants because there is more surface area for water to cling to. And since the size of the pores is reduced, the weight of the water is less and it doesn't run out of the soil so readily.

III. Compare Soils by Growing Plants in Them

Fill flowerpots with soil from the following places: (1) Topsoil from an old fence corner or from a pasture that has never been plowed; (2) soil from an eroded hillside; (3) subsoil from a depth of 3 to 4 feet, which may be taken from a roadbank where the different layers of soil can be easily distinguished; (4) another sample or



two of different soils in your community, for example, from an old lakebed or a woodland.

If you live in the city, take samples from a flowerbed, from an excavation for a building, and from an eroded roadbank.

Plant a few beans in each pot—3 or 4 will be plenty. (Soaking the beans overnight in water hastens germination.) Keep the pots watered and place them where they will be warm and have some sunshine.

At the same time plant 3 or 4 beans in cotton and keep moist.

Compare the rate of growth for several weeks. Keep a record of how fast the beans in each pot grow and how each plant looks. Compare these plants with the ones grown in cotton.

INTERPRETATION

Plants take all their mineral nutrients from the soil. They are made available for plant use through weathering and other soil-forming processes. The minerals found in a soil—except those added in the form of fertilizer—depend mainly on what was in the rock the soil came from.

Some minerals decompose more rapidly than others and even though they occur in small quantities in the soil they set free their nutrient content readily.

Plants also vary in the combination of minerals they can use as plant nutrients.

In general, soils that are above average in organic matter are more productive than soils low in organic matter. Organic matter improves soil in many ways—it makes the soil more crumbly; it increases its water-holding capacity; it serves as a storehouse for plant nutrients such as nitrogen; and it provides food for the countless bacteria and other living things in the soil. Some of these organisms produce acids that in turn help break down soil minerals.

This explains why plants usually grow better in topsoil than in subsoil.

It is possible, however, to find a subsoil that is more productive than the topsoil. This might be true where water percolating down through the soil has leached plant nutrients from the topsoil and deposited them in the subsoil below. It may also be true in desert soils where organic matter seldom accumulates in the surface layer or where alkali forms at the surface and makes the soil toxic for plants.

IV. How Fast Do Soils Take in Water?

You will need 6 large fruit or vegetable-juice tin cans; board 4 inches wide, 1 inch thick, and 12 inches long; hammer; 12-inch ruler; pocket watch with a second hand; pencils and paper; quart measure; and 2 gallons of water. It may take 2 to 3 hours to complete this activity.

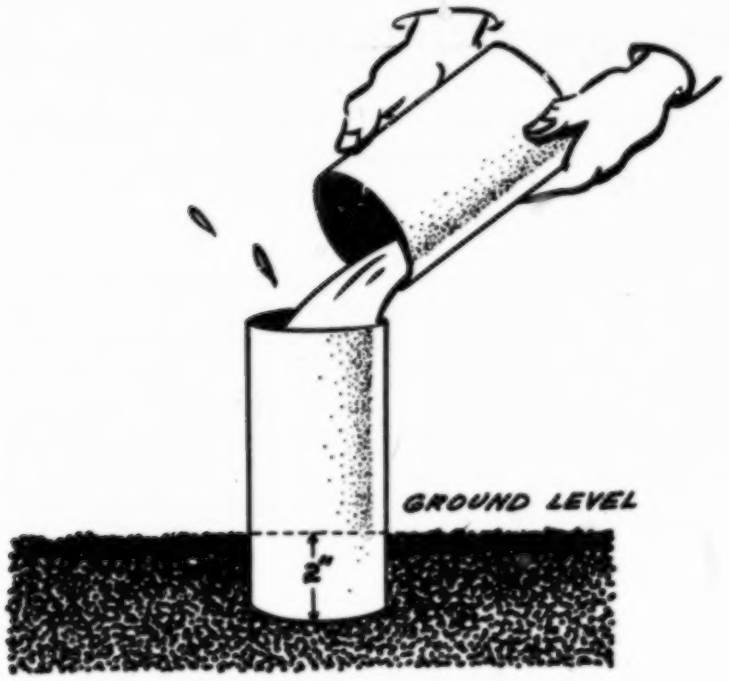
Cut the bottom out of one end of the can just below the rim. This leaves a sharp edge that will drive into the ground easily. Cut out the other end, leaving the rim on for added strength.

Avoiding sandy soil, find a spot in each of the following places:

1. An ungrazed and unburned woodland where there are dead leaves on the ground, ½ to 1 inch or more deep.
2. A grazed woodland where livestock have packed the soil.
3. A fence corner or park where the grass has never been plowed up.
4. A pasture that has been grazed heavily and the ground is packed.
5. A cultivated field where topsoil has all eroded away, leaving subsoil exposed.

Try to locate places close together so that as nearly as possible the same kind of soil is used.

Mark the outside of each can 2 inches from the end without the rim. In each of the spots you have selected, set a can so that the end closest to the 2-inch mark, is on the ground. Place a board on each can and tap with the hammer until the



2-inch mark is level with the ground. Do not disturb the plant material or soil in the can. Avoid spots where sticks or stones make it hard to drive the can down. Add 1 quart of water, and then complete the following record for each location:

1. Place. (Identify as ungrazed or unburned woodland, grazed woodland, fence row, heavily grazed pasture, eroded cultivated field.)
2. Condition of the soil.
3. Presence of leaves or sticks.
4. Time when quart of water was added.
5. Measure amount of water that has moved downward at the end of each minute for the first 10 minutes. Thereafter, note the drop every 10 minutes or every hour, depending on the rate of water movement. (Measure from the top of the can to the water level.)

Compare the rates of water intake. Do the study all in 1 day so that, at the beginning of the activity, the soils will have, as nearly as possible, the same amount of moisture.

Another way to check how fast soils take in water is to go out after a rain following a dry period. Take a spade and dig down to see where the water has soaked the deepest in the following spots: (1) On bare soil where clay is showing, (2) in woodland where there is a good covering of leaves, (3) in a good pasture where there is a heavy sod, (4) on a steep slope, and (5) in a sandy soil.

For leaders of urban clubs who cannot get out into the country, the following will be suitable: (1) An open lawn with good sod that is not walked on much; (2) an area beside the walk or a path that is heavily trampled; (3) a spot within a well-developed clump or row of shrubbery (keep away from paths); (4) a garden or flowerbed.

INTERPRETATION

Rate of water intake determines the amount of water that runs off. The more water that enters the soil the less there is to run off.

But there are other advantages to soils that take in water readily. Much of the rain that falls during heavy rainfalls soaks into the soil and is available for plants later on. And during July and August when rainfall is often light, except for rather intense thundershowers, it is even more important that as much rain as possible soaks into the soil for plant growth.

We have all seen streams running red and brown with soil washed off fields after such summer storms. People experienced in soil and water conservation practices know that erosion-control measures must be designed to handle violent storms. They have learned from research studies that most of the erosion that occurs during the year is caused by these storms.

Plants need air in the soil for best root development and growth as do many kinds of bacteria. Water movement in the soil brings better air circulation. When water enters the soil, air moves out and is replaced by fresher air as soon as the soil pores are again free of water.

The way soil has been managed has a lot to do with how fast it takes in water. Hard farming—using land year after year for cultivated crops with little or no grasses and legumes—uses up the organic matter and causes the soil to become hard and dense. A crust, a fraction of an inch to an inch or more thick, may form over the surface. Laboratory studies at the University of Illinois showed that water moved through a crust only one-third to one-fifth as fast as it did through the soil just below the crust. Other studies showed that water moves through the soil below the plow layer 10 to 30 times faster than through the plow layer itself. This proves the importance of good management in preventing erosion. Farmers who grow grasses and legumes in crop rotations help their soil to take in more water and thus prevent much erosion.

Growing trees, shrubs, and mixtures of grasses and legumes for permanent cover also add organic matter to the soil and prevent the formation of a dense layer or crust.

Gardeners can improve the water intake and retention rate of their soils by adding plenty of compost every year. Since a "crop rotation" may not be practical in urban gardens, it is especially important to apply plenty of organic matter each year and to use winter cover crops.

V. How Does Organic Matter Help Soil Structure?

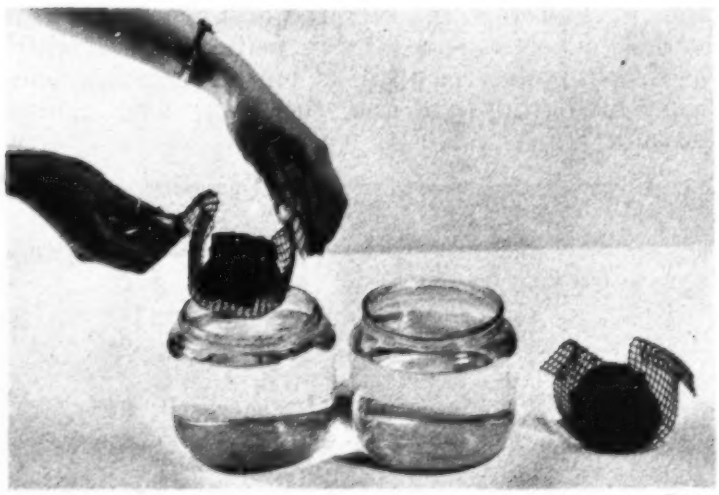
Take two wide-mouthed glass jars. Make two small baskets or wire racks of ¼-inch hardware screen. For each rack you will need a piece of screen about 3 by 10 inches. Bend the wire, as shown in the illustrations, so that it extends, basketlike, down into the jars.

Collect lumps of soil (not sandy) just under the sod from (1) a natural sod fence corner or park and (2) a cultivated field that has been farmed heavily and where the soil is light in color. These lumps should be about twice the size of an egg.

Fill the jars with water within an inch of the top.

Place the lumps of soil in the baskets and lower them gently into the jars.

Watch closely and make notes of what happens.



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INTERPRETATION

Why does the soil from the heavily cultivated field fall apart and drop to the bottom of the jar while the other one holds its shape and clings together? The answer is largely the difference in the amount of organic matter and the effect it has on the soil.

Organic matter has a marked effect on both the physical and chemical properties of soils. It helps soil hold water and, therefore, decreases the amount of water that runs off. It improves aeration, especially on the finer textured soils. And it makes the soil easier to work—improves soil tilth, as farmers would say.

While these are all related, improving soil tilth is the one most clearly illustrated in this simple activity. Organic matter improves tilth of soils—makes the soil crumbly—causing the individual soil particles to stick together tightly in granules. These granules act, in effect, like much larger particles, in letting water and air move through the soil more readily. The large granules tend to stick together, too, because of the binding effect of the decomposed organic matter, or humus, and because of tiny roots under sod layers.

Since organic matter reduces water-runoff losses, damage by water erosion is greatly reduced.

When raindrops strike a bare soil with little organic matter, like the soil samples from the heavily cultivated field, or even when water runs over this bare soil it breaks down and washes away readily.

81,492

These two samples of soil were taken only 25 feet apart. The one on the left from a cultivated field; the one on the right from an undisturbed fence row. Tests show the crumbly soil takes in water 20 times faster than the other.

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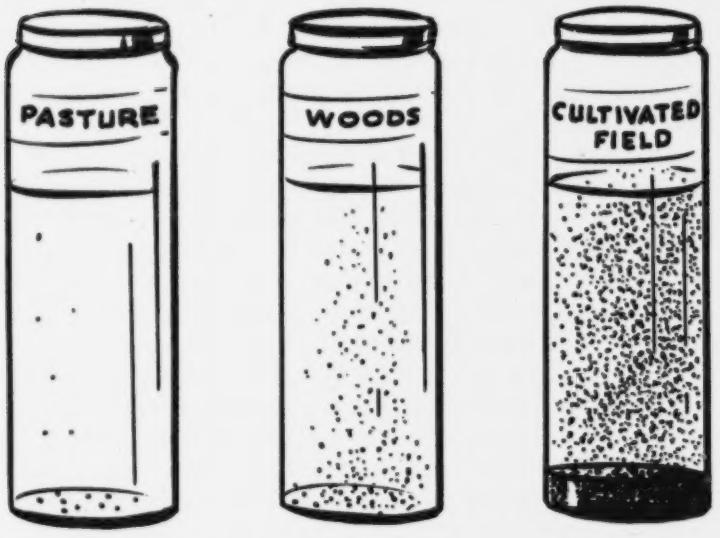
VI. How Much Sediment Does a Stream Carry?

You will need three tall, narrow bottles, such as olive bottles, with tight stoppers for this experiment.



After a heavy rain, fill one of the bottles from a small stream that gets at least a part of its water from cultivated fields.

Then find one stream where all the water comes from woodland and one where the water comes from good pasture or meadow. Fill the other two bottles from these streams.

Allow all three of these samples to settle for a few days. Look at them daily and make notes on what you see.

INTERPRETATION

There is an important story in these three bottles—the story of how sediment washed from farmland hurts the farmer and city dweller in many ways.

Sediment carried by streams hurts the farmer first because it is a part of his farm that is being carried away. Much of it is topsoil—the best soil he has. But a lot of it comes from gullies and roadside ditches, too.

After the sediment leaves the farm some of it gets into streams and begins to affect everyone. More than 3,200 water-supply reservoirs are losing water-storage capacity each year to sediment. Water bills are higher because the water must be filtered.

One-fourth of the electric power generated in the United States comes from hydroelectric plants. The storage reservoirs serving these plants are gradually filling with sediment.

Sediment fills road and railroad ditches, plugs culverts, and clogs stream channels so they must be cleared or the bridges raised. All this increases taxes.

Many harbors must be dredged annually to allow ships to enter.

Floods are more frequent and more serious, partly because the streams are choked with sediment, resulting in less capacity to carry floodwaters.

Silt harms fish by covering up their spawning grounds and shading out light. Many fish actually die during floods when their gills are clogged with silt.

Sediment is a national problem. The national sediment damage amounts to millions of dollars annually.

Soil and water conservation measures applied to farm and ranch land will greatly reduce sediment. Erosion that causes sediment deposition can be reduced up to 90 percent with soil- and water-conservation measures. Growing grass and trees will reduce erosion greatly. This is true because they give protective cover and add organic matter which helps the soil take in water more readily, as shown in Activity IV. Contour farming, contour stripcropping, and terracing also reduce erosion.

79,562

Floodwaters affect everyone. They not only destroy homes and other property but often carry away good topsoil.

VII. Find Out How Much Alive Soil Is

Take 3 large, heavy paper shopping bags, a ruler, a small spade, and 6 or more small bottles with lids or corks. A small magnifying glass will also be helpful. Measure off an area 1-foot square and collect the soil to a depth of 2 or 3 inches from each of the following places:

1. Below the leaves in an ungrazed and unburned woodland.
2. A pasture or fence row, just below the surface.
3. A badly eroded field where subsoil is exposed.

As you remove the soil watch for burrows of worms and other animals. You may also find the eggs of certain insects singly or in masses or pods.

Examine the samples, either indoors or outdoors. If you examine them indoors, small specimens will not be blown away by the wind and you can use a microscope to look for small organisms.

Pour out the samples on separate sheets of white paper the size of an opened newspaper.

Carefully sort the soil, watching closely for small living things. One-foot squares of ¼-inch hardware cloth or window screen will be helpful in making this examination. Place the different kinds of animal life in separate bottles. Count the animal life belonging to each of the following groups:

1. Worms (such as earthworms or night crawlers having no legs).
2. Grubs (any wormlike animal with legs).
3. Snails. (Snails without shells are called slugs.)
4. Insects (any hard-shelled, soft-bodied, or winged (not all have wings) animal with 3 pairs of legs).
5. Spiders, mites, ticks, (animals with 4 pairs of legs).
6. Animals with more than 4 pairs of legs.
7. Others (any animal not falling into one of the above groups).

Which soil sample has the most small animal life? Does this seem to be related to the rate these soils absorbed water in Activity IV?

Does the amount of animal life and the burrows the animals make appear to have any relation to the looseness of the soil?

Figure the total number of animals per acre for each group from each of the sampled areas. (There are 43,560 square feet in an acre.) Also figure the grand total of all of the animals for 1 acre. No matter how large the total number of visible animals you find in the soil, it is small compared to the number of microscopic plants and animals, particularly bacteria, present.

This activity is best suited to spring.

INTERPRETATION

The soil is the home of innumerable kinds of plant and animal life that range in size from those too small to be seen with a powerful microscope to large ones such as earthworms. Most of the living organisms in the soil are so small you will not be able to see them without a microscope.

These living organisms have a marked effect on the characteristics of the soil itself. At the same time, such soil characteristics as the granulation (structure) of soil, how well air moves through it, how wet it is, how much organic matter it contains, whether it is sweet or acid, how the farmer handles his soil, all strongly affect the number of organisms in the soil.

Plantlife that is too small to be seen without a microscope includes bacteria, fungi, and algae. Bacteria, 1-celled organisms, alone may be present to the extent of 1 to 4 billion per gram of soil. Fungi, which include molds, do not contain chlorophyll and therefore cannot manufacture their own food. A gram of soil contains from 8,000 to 1 million of these. Soil algae are microscopic plants that contain chlorophyll and may run as high as 100,000 per gram of soil under favorable conditions.

Animal life in the soil includes protozoa, microscopic animals larger than bacteria; nematodes, larger and more complicated than protozoa but some still too small to be seen without a microscope; and earthworms, ants, snails, spiders, mites, and various other worms and insects. It is only specimens of this last group, and possibly some of the larger nematodes, that you will see in this study.

Earthworms are the most important group of the larger animals. They live in soils that are high in organic matter and not too sandy. The number of earthworms may range from a few hundred to more than a million per acre. Under favorable conditions between 200 and 1,000 pounds of earthworms may be present in an acre of soil.

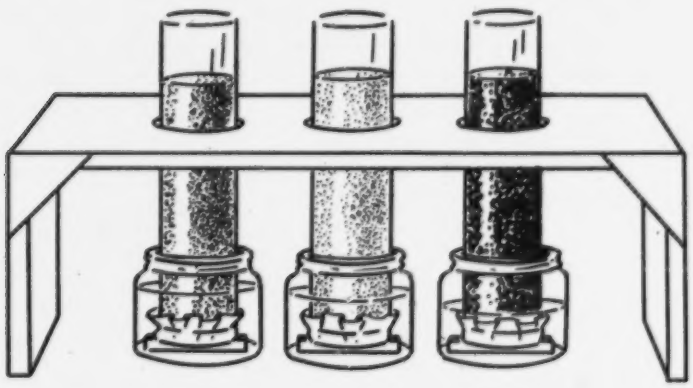
The earthworms in an acre of soil pass several tons of soil through their bodies each year and in so doing make certain nutrients available to plants. Burrows left by earthworms let water and air move

more freely through the soil. Earthworms also bring soil from lower levels to the surface, thus mixing the soil.

In addition to earthworms, some rodents, ants, snails, spiders, mites, millipedes, centipedes, and various other worms and insects spend all or a part of their lives in the soil. The effect of these animals on the soil is beneficial for the most part. Because of their burrowing habits, for example, a lot of soil mixing takes place. They improve soil aeration and drainage. Some of them, however, feed on the farmer's crops. But it is evident that the animals in the soil are vital and contribute greatly to the way a soil functions. Soil-inhabiting plants and animals are largely responsible for converting the nutrients in undecayed organic matter to inorganic forms that growing plants can use.

VIII. See How Capillary Water Moves Through Soil

You will need 3 old-fashioned lamp chimneys or glass or plastic cylinders plus 3 small pans or low wide-mouthed glass jars, some thin cloth, and some string or rubber bands.



Fasten the cloth over the top of the lamp chimneys or the cylinders. Turn them upside down and fill each three-fourths full with one of the following dry soils:

1. Sand.
2. Clay soil. This kind of soil is sticky when wet and dries in hard clods. Grind up the clods and put the dry clay in the chimney.
3. Dark, crumbly soil like that found under good grass sod. Or get topsoil from a garden or commercial nursery.

Jar the cylinders slightly by bumping on a table to settle the soil. Be sure the soils are dry.

Set the cylinders in the jars and pour water in the jars—do not pour water in the cylinders.

Keep a record of how long it takes the water to move up 1 inch, 2 inches, and 3 inches in each cylinder. Note how long it takes for the water to reach the top or whether it ever reaches the top.

The idea is to compare the capillary movement of water in coarse, medium, and fine soil particles.

INTERPRETATION

Moisture moves through soil in all directions, even against gravity, by capillary movement. This movement is caused by the attraction water molecules have for each other as well as the attraction between water molecules and soil particles. Water molecules cling together and form droplets in the air or on a greasy surface where there is nothing to interfere. But when a drop of water falls on soil particles, it spreads out as a thin film over the soil particles—because the attraction between the soil particles and the water molecules is greater than the attraction between the water molecules themselves. Water that moves through soil this way is known as capillary water.

How far and how fast capillary water will move in a soil depends on the size of the soil particles and the condition of the soil. If the spaces around the soil particles are large, the attraction between the water molecules and the soil particles will not be enough to overcome the weight of the water and it will not rise appreciably; however, what movement it makes will be rapid because there will be little friction. This is true in sandy soils.

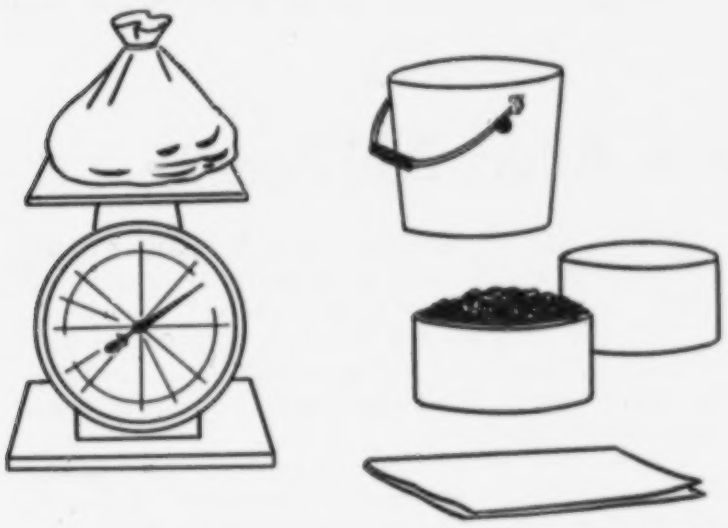
On the other hand, in fine-textured soils the particles are closer together and the attraction between soil and water is greater. Water may then be expected to rise more slowly but higher in soils of fine texture.

Under field conditions moisture moves from wetter soil to drier soil. The difference is not always great, therefore capillary water moves slowly and not far. Even so, enough moisture moves a short distance to the roots of growing plants to make it an important plant-soil relationship.

Much soil moisture can be lost when capillary water moves to the surface and evaporates. Using mulches can reduce this.

IX. Compare How Much Water Different Soils Hold

You will need 2 cans of equal size (coffee cans will do); two 18-inch squares of cloth; some heavy string; a package or similar scale that will weigh up to 5 pounds; and a container of water, such as a 2- or 3-gallon bucket or a 5-quart oilcan with the top cut out.



Put equal volumes of soil in the two cans. Take the soil for one from a field or garden that has been cultivated for several years and that shows lack of organic matter. This sample should be hard and cloddy. Get the other from a well-managed field where grasses and legumes have been grown, or from a good pasture or similar location. This sample should be crumbly and free from clods.

First allow the soils to dry.

Empty the two soil samples on the cloth squares, pull the corners together, and tie with a heavy string. Weigh each sample and record the weight.

Saturate each bag of soil by holding it in the water long enough to soak thoroughly. Remove the soil samples from the water and allow them to drain off the free water for a few minutes. Then weigh again and record the weights.

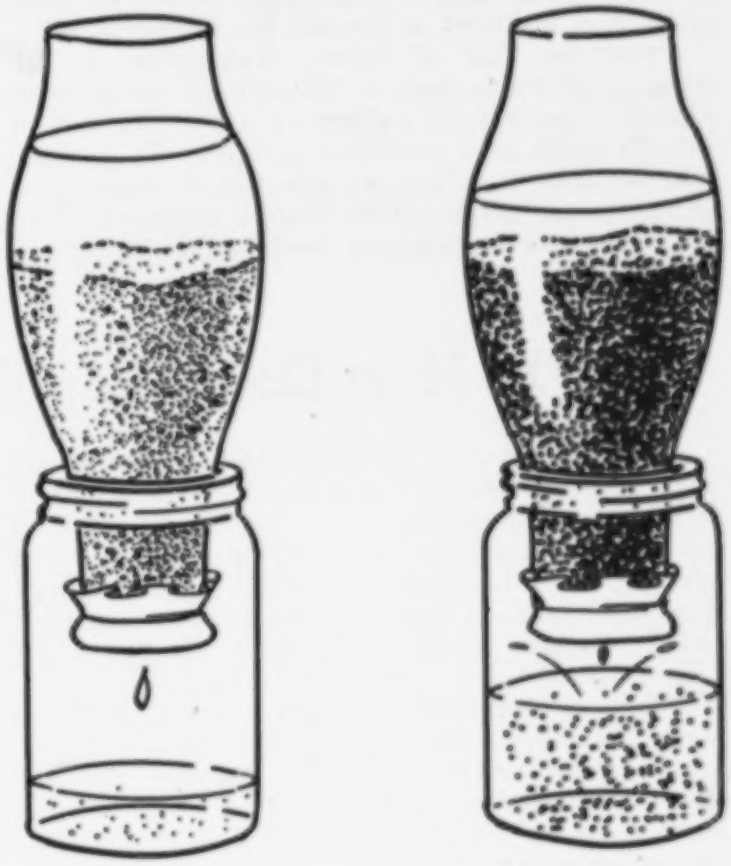
Calculate the difference in weight.

Another way to measure the water-holding capacity of soils is to use two old-fashioned lamp chimneys or cylinders as in the previous activity. Tie a cloth over the top, turn them upside down, and fill them about two-thirds full with the same two soils.

Be sure the soils are equally dry.

Place the chimneys in small-mouth fruit jars, as shown in the drawing.

Pour a pint of water into each chimney. Then note how long it takes the water to begin to drip into the jars, how much water comes from each soil, and how long the water continues to drip.



INTERPRETATION

When organic matter is used up, soil packs together. Thus, a cloddy soil has fewer air spaces, its particles do not cling together in granules, and the lack of organic matter means that it weighs more than an equal volume of crumbly soil from a well-managed plot.

Not only does a crumbly soil take in water faster than a cloddy one, it holds more. The thoroughly decomposed organic matter (humus) in a crumbly soil can absorb lots of water. On a dry-weight basis, this humus has a water-holding capacity of several hundred percent and may act like a sponge. In addition to the water held by the organic matter itself is the water held in the pores between the soil particles and between the soil granules. Hundreds of very fine soil particles are glued together by the organic matter into soil granules.

This increased water-holding capacity of soils high in organic matter under natural conditions makes a big difference in the intake of water. These well-managed soils can absorb most of the rain and snowmelt (if the soil is not frozen). This means there will be less erosion. Streams will run clear. Of course, when the soil is saturated by a long period of rainfall, any additional water then runs off. But until the soil is saturated it will

store up water and let it go gradually. The result is that floods are less severe, water seeps to streams slowly and over a longer period of time, and water is stored in the soil for plants to use.

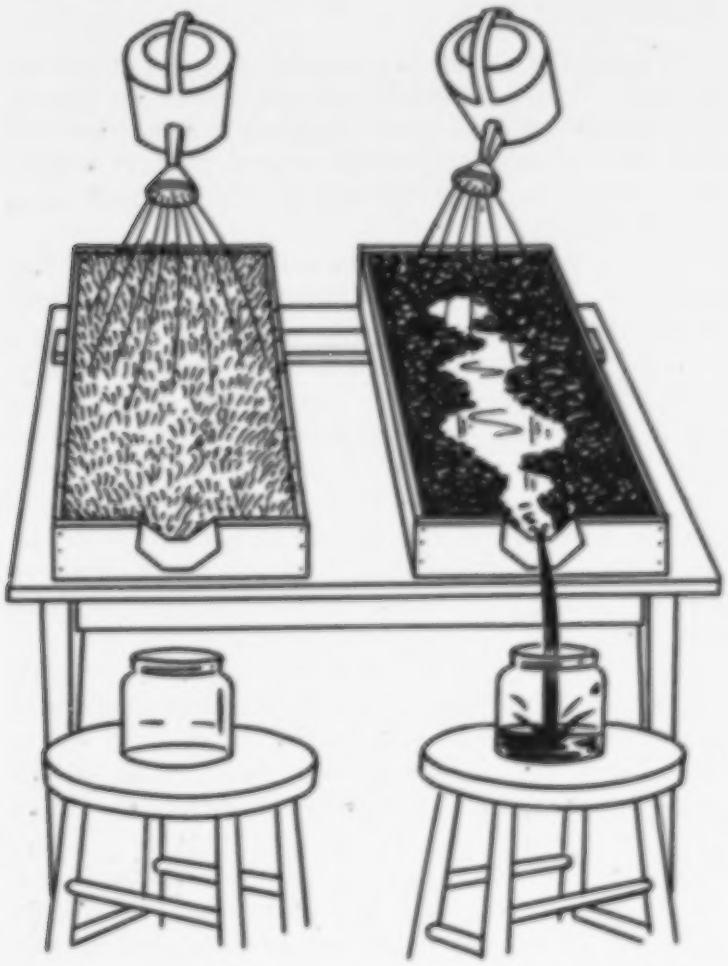
Crops use lots of water. Vegetables use an average of 2 acre-feet, or 650,000 gallons an acre. Cotton takes 800,000 gallons an acre. An acre of alfalfa needs over a million gallons. To produce one ear of corn takes over a barrel of water. Organic matter helps soil store more water and thus helps prevent erosion and produce better crops.

Many field tests have shown the improved water-holding capacity of well-managed soils that have enough organic matter to keep them crumbly and granulated. One deep soil in Texas that was high in organic matter held 25 percent or 1 inch more water in the 1-foot surface layer, after the free water had drained off, than the same depth and type of soil in another field where the soil was low in organic matter. This made a difference of 27,000 gallons of water per acre in the first foot of soil.

X. How Does Crop Cover Affect Soil Loss?

On land that must be cultivated and cannot be kept in grass all the time, farmers can keep the land covered as much of the time as possible by using crop rotations. By growing a cultivated crop like corn followed by a small grain crop and 1 or more years of grass-legume meadow, the land can be covered much of the time. Mulches can help in gardens.

You will need two small boxes about 16 inches long, 12 inches wide, and 4 inches deep. (These boxes can be used for several activities so they are worth making and keeping on hand.) Make them watertight by lining them with plastic material, tin, or tar paper.



At one end of each box cut a V-notch 1 to 1½ inches deep and fit with a tin spout to draw runoff water into a container (see drawing).

You will also need 2 flower sprinklers, at least a quart in size (half gallon is better); 2 half-gallon wide-mouth fruit jars; and 2 sticks of wood about 1 inch thick.

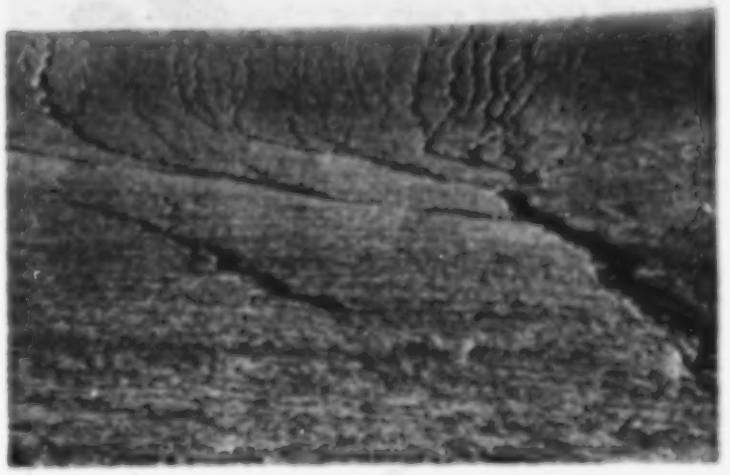
Cut a piece of sod from a pasture, lawn, fence row, or the like, to fit one of the boxes. Trim the grass with scissors so that it is not more than an inch high. This makes it easier to handle.

Fill the other box with soil from the same place—no grass, just soil, but don't try to pick a very poor soil. The idea is to have the same kind of soil in the boxes, one with grass, the other bare.

Set the boxes on a table so that the spouts extend over the edge. Place the sticks under the other end to give them slope.

Put the empty fruit jars on stools placed beneath the spouts.

Fill the two sprinklers with water and pour the water on both boxes at the same time. Pour steadily and at the same rate for both boxes. Hold the sprinklers the same height from the boxes. About



S-47

This is what happens when heavy rains fall on bare fields.

a foot will be satisfactory, although you can get various results with different heights.

INTERPRETATION

You will find that the water will rush off the bare soil into the fruit jar, taking soil with it. The flow will stop soon, but the jar will contain muddy water.

The water that flows from the sod will be reasonably clear. It will take longer for the flow to start and it will continue longer. Also, not as much water will reach the jar. The amount of water in the two samples before the experiment will affect the results somewhat. Unless the soils are waterlogged, however, the activity will be successful. The samples need not be completely dry.

This activity illustrates one of the most fundamental principles of soil and water conservation—the protection grass gives soil against the pounding of raindrops and the movement of running water.

The grass breaks the force of the raindrops so that the soil is not pounded and broken apart by this impact. The grass roots open up channels to let water get into the soil. Organic matter furnished by decayed grass crops also lets water

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Grass protects the soil and increases meat and dairy products.

enter more readily, as we learned in Activity IX. And as the water runs off, the stems of grass slow it down so that it does not have enough speed to disturb the soil.

Experiments show this is true. For example, on one plot at La Crosse, Wis., where corn had been grown every year for 6 years, the annual soil loss was 89 tons per acre. On a plot in bluegrass sod, however, the annual soil loss was only 0.2 ton per acre.

XI. How Does Mulch Prevent Soil Loss?

Use the same boxes you made for Activity X. This time fill them both with the same kind of soil.

Set them on the table as before, placing the sticks under one end to make a slope.

Cover one box of soil with a thin layer of straw, grass, wood shavings, or sawdust; leave the other one bare. Sprinkle water on both boxes, using the same amount of water and pouring at the same rate from an equal height.

Note how much and how fast water runs off into each fruit jar.

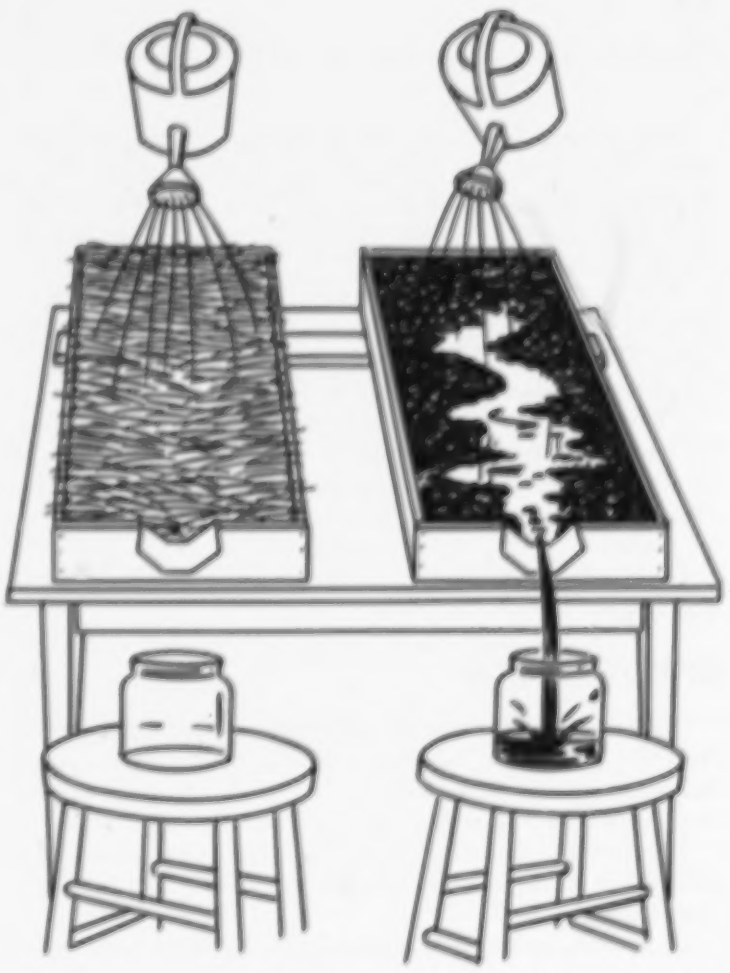
Another way to study the protection of mulches on the soil is to drop water from a short height on soil that is not protected and on soil that is protected with a mulch.

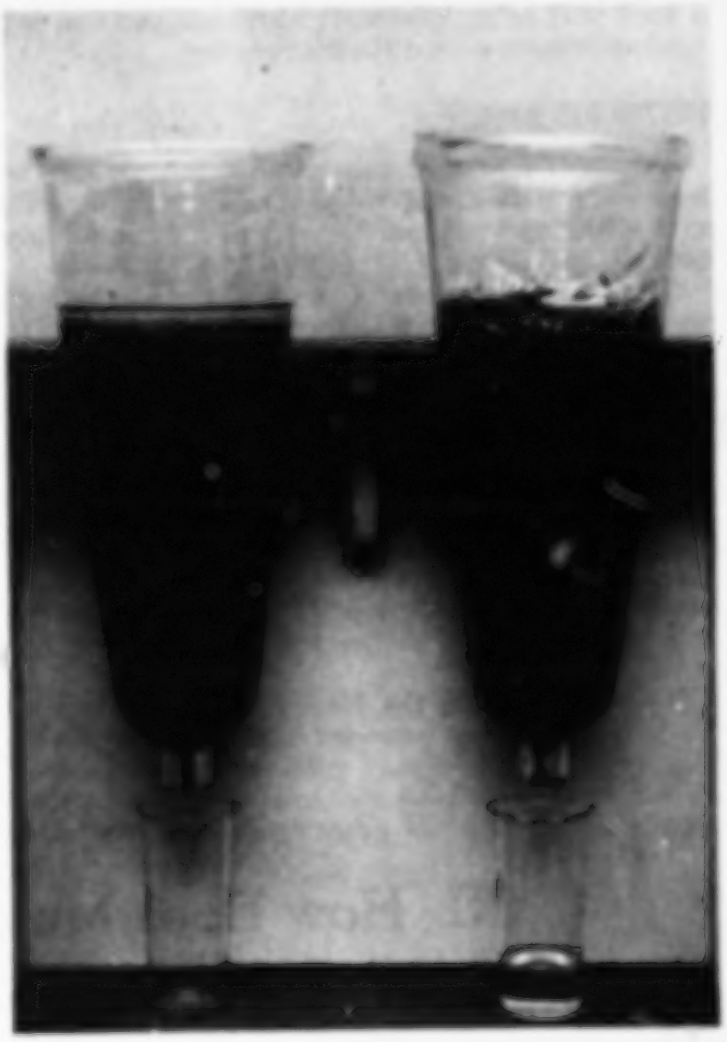
For this you will need two small tin cans. With an 8-penny nail, punch a hole in the bottom of each can and fill the hole loosely with cotton.

Put one-half inch of soil in two small fruit jars or water glasses. Put a light layer of dry grass clippings on one of the soil samples. Leave the other one bare.

Arrange the tin cans so that they are about 4 feet above the jars of soil. Put about one-half inch of water in the cans. Large drops of water will form through the holes in the cans and drop on the soil in the jars. Note the amount of soil that is splashed on the sides of the glass.

The third activity shows the effect of mulch on water intake of soil as well as the value of mulch in conserving soil and water.





Use a clay loam soil if possible. But any good loam that you can get from a flowerbed or from a grassed roadside will do. Work slightly damp soil into a good tilth by pressing it through a wide-mesh sieve.

Fill two beakers with openings at the bottom about two-thirds full of the soil. Leave one sample bare and cover the other with a layer of grass clippings, clipped straw, or fine shavings.

Place a glass jar below each beaker. Pour water on the soil from a height of about 1 foot. Use a sprinkler or a can with holes in the bottom. Make the holes large enough to give a heavy sprinkling of water.

Compare the amount of water that drips through the beakers into the jars.

INTERPRETATION

Water impact puddles the bare soil, clogging the surface pores. The result is that the soil cannot take in water. In a field, most of the water would run off rather than enter the soil.

By protecting the pores at the surface of the soil with a mulch, water enters and moves down through the soil.

A mulch, such as straw, grass, or shavings, pre-

Using a subsurface cultivator, farmers can till the soil and still leave some of the residue from the crop before on a mulch to protect the soil.

vents the puddling or "running together" of the surface soil under the impact of raindrops. Dead plant materials protect the soil from being detached by raindrops. As long as the soil is granulated water will soak in rapidly. However, water soon softens the binding material that holds the granules together, and then the granules and clods disintegrate. The impact of raindrops separates the fine particles, splashing them into the air. Then these particles accumulate on the soil surface and fill the spaces between larger particles and granules. The result is a "seal" over the surface that permits water to enter the soil very slowly, if at all. Water must then run off. If the land is sloping, it causes erosion during hard, beating rains.

Mulches also reduce evaporation by shielding the soil from the wind and from the direct rays of the sun. In addition to mulches, high organic-matter content of the soil itself is needed.

XII. What Does Contouring Do?

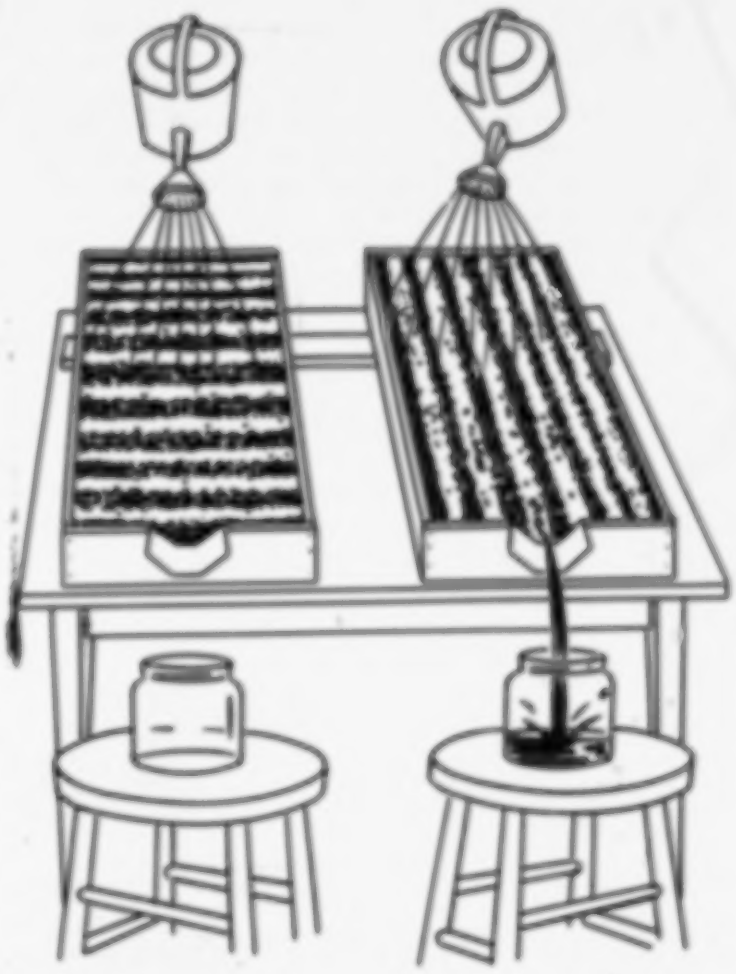
Fill both boxes used in Activities X and XI with soil taken from the same place. Set them on a table and place the sticks under the end to make a slope. Place fruit jars below the spouts of the boxes as before. Using your finger or a pencil, make furrows across the soil in one box and up and down the soil in the other.

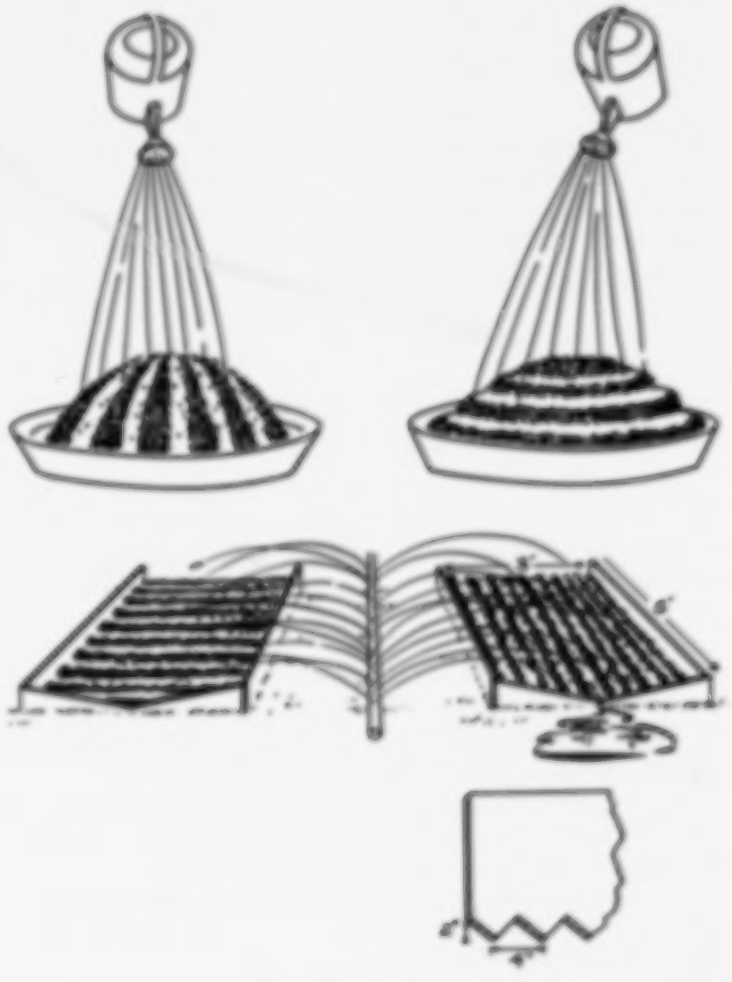
Fill two sprinklers with water and slowly sprinkle the two boxes at the same time. Hold the sprinklers the same height above the soil and pour at the same rate. Compare the rate of flow into the two jars and note the difference in their contents.

Another way to do this is to put mounds of soil in the middle of the boxes or in 2 large round low dishpans. With a pencil or your finger make furrows up and down one of the mounds and circles around the other mound. Sprinkle an equal amount of water on each mound and observe the water. Remember though, that such mounds probably have much steeper slopes than most cultivated land.

You can do this in the yard if you have a sloping area where there is no grass or where the grass is badly worn by walking or playing. By doing this outdoors, you can use a larger area. Make two plots 3 feet wide and 5 feet long with 1 or 2 feet between them.

With a regular garden hoe cut grooves 4 inches apart and about 2 inches deep across the slope





Hard rains won't make gullies in waterways kept in grass.

Cultivating row crops on the contour helps to hold water until it soaks into the soil. Much runoff and soil loss are prevented.

on one plot and up and down the slope on the other. Notches cut in the edge of a 1- by 12-inch board (as shown in the drawing) can make the grooves.

Lay a perforated lawn-sprinkling hose between the two plots and turn it on so that a steady shower falls on both plots with equal intensity.

Make careful notes of what happens on both plots.

INTERPRETATION

Contour farming is one of the easiest and most widely accepted conservation practices. It is the use of implements across the slope of the land; that is, on the contour. When a farmer farms on the contour he disregards the usual straight field boundaries and straight-rows and follows curved lines whenever necessary to stay on the contour.

Contour farming should be used in combination with crop rotations, grass waterways, fertilizers, and returning organic matter to the soil. Contouring alone will not stop erosion. But it reduces soil erosion as much as 50 percent on a wide range of soil and slope conditions. Steepness and length of slope are important, as well as the crop grown and the condition of the soil.

There are other advantages of contour farming. In low-rainfall areas it helps hold and conserve rainfall. Farmers have found that it saves power, time, and wear on machinery because the equipment is working at peak efficiency all the time instead of being overloaded going uphill and underloaded coming downhill.

Cultivation on the contour helps prevent erosion and saves rainfall in gardens on sloping land.

XIII. Make Splash Boards To Study Splash Erosion

Get 2 boards 1 inch thick, 4 inches wide, and 3½ feet long. Sharpen one end of each board. Paint them with flat white paint. Mark lines across the boards at 1-foot intervals beginning at the unsharpened end. Attach a tin shield about 4 inches wide and from 8 to 10 inches long to the top of each board (see drawing). The shield helps to prevent rain from washing off the splashed soil.

Locate two spots with very different amounts of grass cover. Some suggestions are:

1. A bare or nearly bare spot in the schoolyard where the grass is well trampled and an untrampled spot where the grass is heavy.

2. A spot on each side of a farm fence where grass is heavy on one side and thin or the ground bare on the other side.

3. A field in a cultivated crop like small corn, cotton, or vegetables and a meadow where a grass-legume crop is growing.

Drive the sharpened boards into each of the two spots to a depth of 6 inches.

Leave them there and observe them after the first rain.

Or fill a sprinkling can and, holding it the same height (3 to 5 feet) above the two spots of ground, sprinkle an equal amount of water an equal distance from each stake (about 1 foot).

After the rain, or after using the sprinklers, note the difference in the amount of soil splashed and the height it is splashed on each board.

Another way to note the removal of soil by splash erosion is to place some coins or flat stones on bare soil and use a sprinkler as before. Observe what the falling water does to the soil around the coins.

You can show this indoors if you place a jar lid full of soil in the center of a white sheet of paper or cardboard about 3 feet square and hold a sprinkler over it.

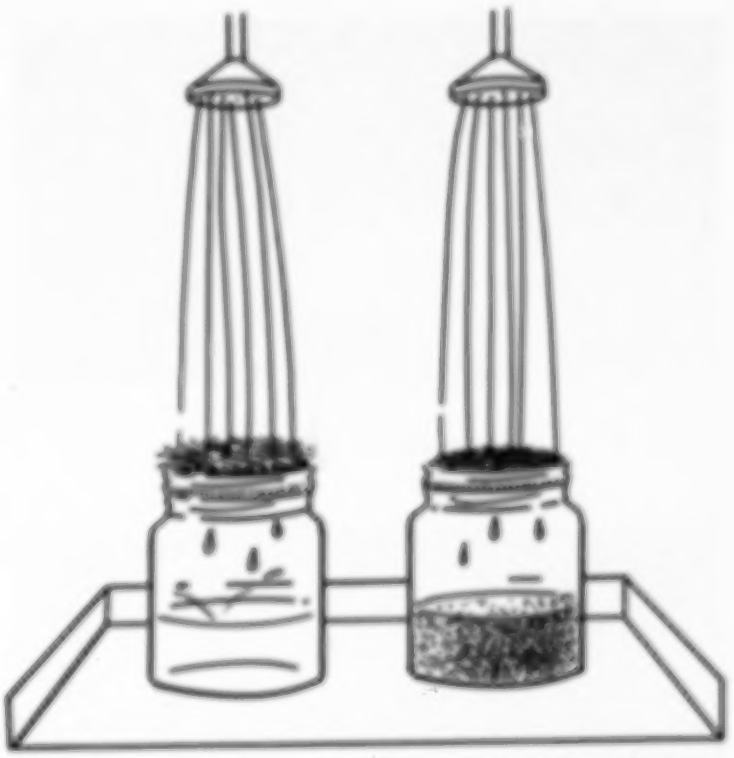
You can show the value of soil cover in preventing splash erosion by placing perforated fruit-jar lids, topside down, over two pint fruit jars. Fill each lid with the same kind of soil, level full. Place grass clippings on one and leave the other one bare. Set the lids side by side and hold a sprinkler over both, letting the water fall about 3 feet. Observe what happens to the water.

The bare soil will be splashed out of the lid. More water will soak through the sample with the grass clippings.

INTERPRETATION

You can observe the effects of splash erosion after any hard rain. Small pebbles will be perched on pedestals just as the coins were.

You can also see splashed soil in gardens and schoolyards, on sidewalks, on vegetables and



flowers, on basement windows and picket fences. One of the reasons for mulching strawberries is to keep splash off the fruit.

Soil particles must be dislodged before they can be moved. This is one part of the erosion process. When raindrops fall on bare soil, much energy is expended. Small clods and soil granules are broken down by the impact of the falling drops of water. Studies made by the Soil Conservation Service show that from 1 to 100 tons of soil per acre may be splashed into the air during one rain. This splashed-up soil consists of single particles that have been dislodged from the soil mass. Thus, they are easily transported from their original location by any water movement on the surface, no matter how slight. There need not be a steep slope for this kind of erosion since fine particles can be carried by slow-moving water.

You will find that soil particles are splashed to

Small pieces of stone are left on pedestals of soil after heavy rain has carried away the soil around them.

A raindrop splash.

Rye seeded in corn in the hill as a cover crop protects soil from erosion during winter and spring.

A dense stand of wheat or other close-growing vegetation breaks the force of raindrops, allowing them to fall gently to the ground.

a height of more than 2 feet and may be moved more than 5 feet horizontally on level surfaces. On steep slopes soil particles fall downhill and therefore result in considerable soil movement without being carried by water.

Fine soil particles are the most easily moved. This results in erosion of the fine particles such as silt and clay, leaving only sand and gravel on the surface. You can see this in cultivated fields after hard rains.

Any kind of crop cover cuts down soil movement. A hayfield would not lose as much soil as a cornfield, especially where the corn is small. After the corn gets large enough to cover the ground between the rows, the leaves will break the impact of falling rain, and any erosion that follows will be caused by the movement of water on the surface breaking loose the particles, not by raindrop splash.

Also, soil erosion will be more severe on cultivated fields during early spring when the ground is bare before the crop gets started and where spring rains are heavy.

In the South where the ground does not freeze during the winter when rain is normally heavy, cover crops reduce splash erosion.

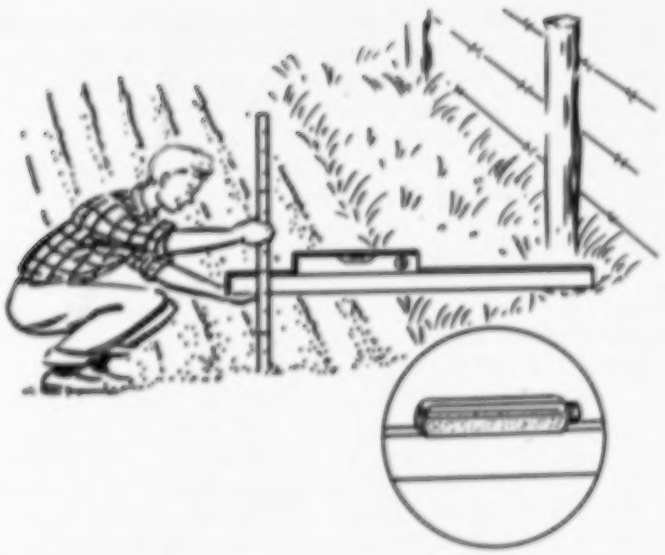
XIV. Measure the Slope of a Field

Slope is expressed in percent, meaning the number of units the land falls (or rises) in 100 units of horizontal distance. You can measure how steep a slope is with some simple materials.

You will need a yardstick, a straight stick exactly 50 inches long, and a carpenter's level or a flat bottle half full of a colored liquid. Go out on the farmyard or to any place you would like to know how steep the slope is. Place the 50-inch stick horizontally on the ground (one end will be higher than the other because of the slope), as shown in the drawing. Put the level (or the bottle) on the 50-inch stick, and move the free end of the stick up or down until the bubble (or the water) shows that the stick is level.

Read on the yardstick the distance from the ground to the bottom edge of the horizontal stick. This reading in inches, multiplied by 2, gives the percent of slope.

If you use a stick 100 inches long, then the reading on the yardstick would give the percent of slope and you would not need to multiply by 2.



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Contour stripcropping combines alternate strips of a row crop and small grain or grass and legumes and thus protects the field from erosion while growing a cultivated crop.

INTERPRETATION

Slope is a very important land feature. It often determines whether a piece of land should be used for grass, trees, or cultivated crops.

The size of particles moved by water ranges from the smallest clay particles, carried in suspension, to large stones and boulders that slide or roll along on steeply sloping stream beds.

Water flows slowly over a gentle slope and rapidly over a steep one. Since the slope of a field itself cannot be changed, a farmer needs to do what he can to slow the movement of water down his slopes. Growing grass or trees, or using conservation measures like contour farming and stripcropping will help. Or he may shorten the length of slope by building terraces and diversions.

But reducing the speed of the water is essential.

Increasing the velocity of a stream increases its cutting or eroding power. The greatly magnified power of swift currents as compared with that of slow ones explains the work of streams at flood stage on steep slopes.

OKLA-6470

A broad-base terrace or channel on the contour collects runoff water and carries it safely from the field.

XV. Measure Amount of Soil Loss

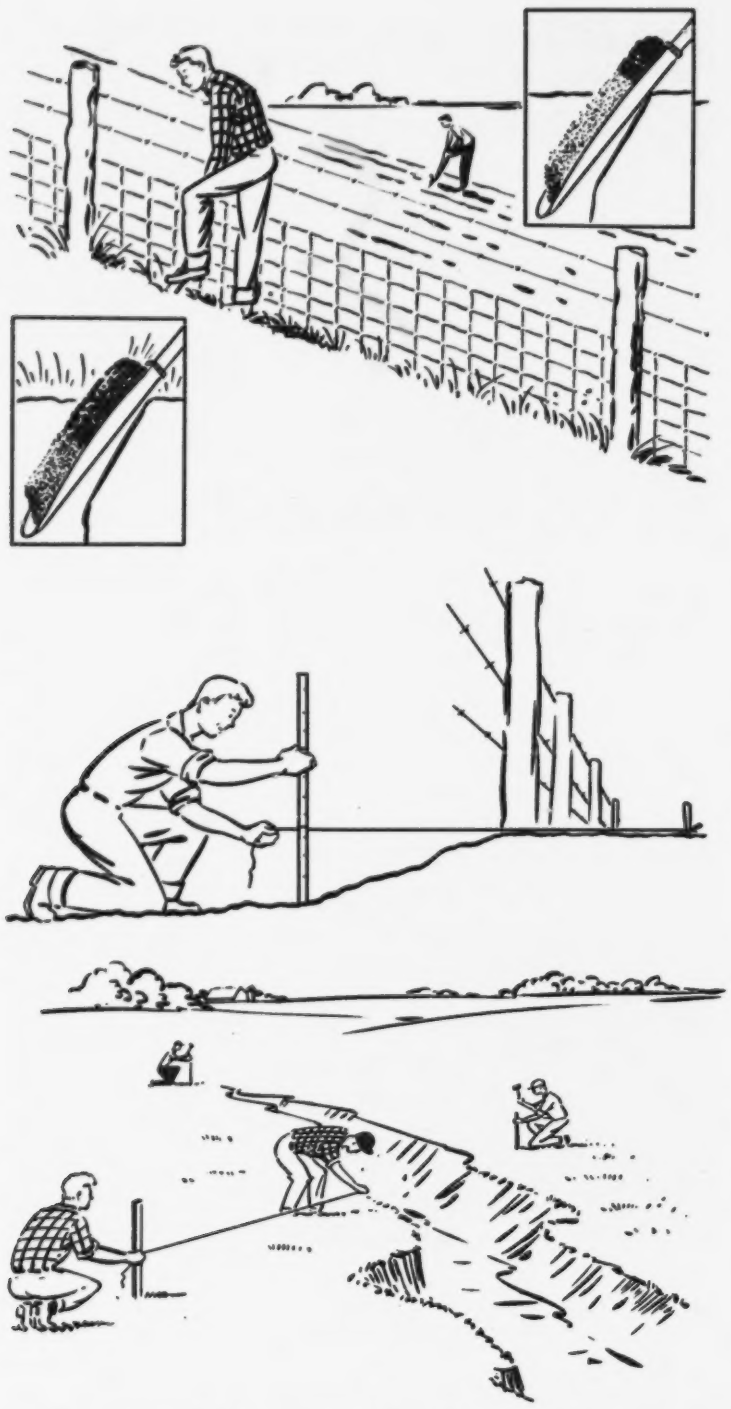
You can measure how much soil has been eroded away in several ways. You may want to try one of the following in your neighborhood:

1. Find a cultivated field where the slope has at least a 5-foot fall in 100 feet of horizontal distance. Try to find a field that has been in cultivation for some time. You can check this information about the farm with the owner or the neighbors.

Dig a small hole deep enough to get below the topsoil layer. Then cut off a slice an inch or more thick along the vertical side of the hole. Lay this slice on the ground and study it. Note the depth of the topsoil layer. Study the structure—how the particles are held together. Are they tight and does the soil hold together in large lumps (clods)? Or is it crumbly like cake?

Dig another hole in the fence row at the edge of the field or just across the fence in a pasture that has not been plowed. Try to dig the second hole at about the same point on the slope and as close to the first one as possible. Study the soil layers as you did with the first sample. Lay the two samples side by side and compare them. Compare the depth of the topsoil layer and the structure of the soil.

2. Find a field where there is a fence built *across* the slope. Compare the height of the land at the fence row with that in the field down the slope. To do this attach a string to a stake driven in the ground above the fence row. From a spot down the slope (see drawing), pull the string parallel



to the ground line above the fence and measure from it to the ground.

3. Measure the growth of a gully. Find one that is cutting deeper and farther into the field with each rain. Drive wooden pegs 10 to 15 feet above the gully head and on each side of the gully (see drawing). After each rain, measure from each stake to the nearest edge of the gully to see how much the gully has grown. Do this after several rains and compare your measurements to see how much the gully has grown since you first set the stakes. By measuring the width, depth, and length of the gully, figure out how many cubic feet of soil have been lost.

INTERPRETATION

Soil washed from a field is not necessarily lost forever. But for all practical purposes it may be lost for a very long time. The soil that fills the bottom of a lake, for example, is still soil, but it is useless for agriculture. Soil that is piled deeply at the lower edge of a field covers other soil, making it useless. And soil that is carried to the sea may lie there, turn to rock, and later be raised from the ocean floor by geologic action to be broken down again into soil.

The first person to suffer from loss of soil usually, though not always, is the farmer. Many experiments have shown that in general the deeper the original topsoil the higher the yield of crops. In Missouri topsoil 12 inches thick produced 64 bushels of corn per acre while topsoil 4 inches deep produced 38 bushels. The soils were side by side and received the same treatment.

In Washington, wheat yielded 35 bushels per acre on topsoil 11 inches deep, but only 23 bushels on topsoil 5 inches deep.

So the farmer loses when he loses topsoil. His crop yields go down. The cost of producing each bushel of grain or pound of meat goes up. And, he makes less money or even loses money.

People who do not live on the land depend on the farmer to grow their food. The surplus that he grows becomes their three meals a day. Actually, whole civilizations depend on this surplus. The primary producers—the farmers—must supply a surplus of food, clothing, shelter, and other necessities before the artisans, engineers, scientists, philosophers, writers, and others can live. Few nations ever advanced their civilization while all their people produced their own food, clothing, and shelter directly from the soil.

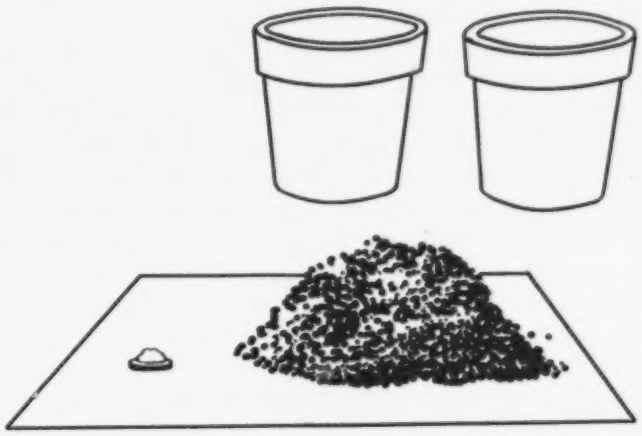
We can find plenty of evidence that countries that lost their ability to produce a surplus actually lost their civilizations too. All across the continent of Asia and into Europe and North Africa, for example, you can find centers of former civilizations that are now among the backward areas of the world. It is true that conquering hordes that repeatedly overran these countries sacked and razed the cities. But where soil and other resources remained the cities were usually rebuilt. It was only after the land was depleted or exhausted that the fields became barren and the cities were not rebuilt.

How badly has erosion hurt America? According to the best information we now have, 25 million acres of land once suitable for cultivation has now been lost. Every year we are losing another 400,000 acres to erosion and 100,000 acres to waterlogging, salting, and sediment deposition. In addition to these losses, every year more than a million acres are being taken out of agricultural use and put into highways, urban development, airports, and other nonagricultural uses.

What about the land we now have? Of our total of 478 million acres now in cultivation, 121 million is subject to a critical rate of damage. Another 128 million is subject to serious damage.

XVI. How Does Fertilizer Affect Plant Growth?

You will need two flowerpots. Try to get pots that hold about a quart.



You will also need soil of low fertility; seeds of tomatoes, beans, corn, or wheat; nitrogen and phosphorus fertilizers; and clean sand.

Get the soil from an eroded bank or from an eroded field that has been farmed heavily. Or dig into the soil a foot or more and get subsoil.

For the nitrogen fertilizer use ammonium nitrate or ammonium sulfate. And for the phosphorus fertilizer use superphosphate.

Place about 1 pint of soil on a sheet of paper. Add to this soil one-half as much nitrogen fertilizer as can be heaped on a dime. Then add the same amount of phosphorus fertilizer. Mix these fertilizers thoroughly with the soil.

If the pots hold a quart, then put a pint of the original soil in one pot and finish filling it to ¾ inch of the top with the fertilized soil.

Fill the other pot to ¾ inch of the top with unfertilized soil.

Plant a few of the same kind of seeds in each pot and cover with about one-fourth inch of sand to prevent soil crusting. When the plants are well established, thin them to the same number in each pot. Leave 2 or 3 corn or tomato plants, 5 soybean plants, or about 12 wheat plants. Watch their growth for several weeks.

INTERPRETATION

Soil fertility is a major factor in soil conservation. By adding fertilizer and lime when needed to keep soils highly productive, we not only help conserve the soils themselves, but aid conservation in general.

Dr. Emil Truog, famous soil scientist of the University of Wisconsin, points out several ways in which high soil fertility aids conservation.

1. High soil fertility produces a heavier plant growth that protects soil from washing and blowing. Land that is protected with a good cover of grass or trees does not wash. In fact, under many such conditions, soil is being formed faster than it is eroded away. Where native vegetation is removed and cultivated crops are grown, leaving the land bare part or all of the time, erosion takes place.

Keeping the land covered as much as possible is one of the best ways to prevent erosion but plants will not grow abundantly unless the soil is fertile.

2. Heavy plant growth resulting from high fertility uses more water than the growth on poor soil. This leaves room for the soil to hold more water from each rain, thereby reducing runoff.

All growing plants remove tremendous amounts of water from the soil and then allow it to escape as vapor through tiny holes in the leaves. The higher the fertility of the soil the larger the amount of water put to good use and the greater the crop yields.

3. Fertile soil takes in water from rainfall readily, thus reducing the amount that runs off.

Well-managed soils develop a granular structure in which the finer particles join together and form granules or crumbs. These crumbs vary in size up to that of buckshot. Each is made up of hundreds of small particles, some so small they cannot be seen even with a microscope.

Clay soils especially must be granulated to take in water readily. Generally, the most practical way to increase granulation is to provide organic matter.

A farmer can provide additional organic matter for his soil in many ways. He can grow crops or even weeds to be left on the land. He can add manure or return crop residues.

Legumes such as clover, alfalfa, peas, and beans have the advantage of adding extra nitrogen taken from the air. The supply of nitrogen over 1 acre would be worth more than $6 million if it were transformed into nitrogen fertilizer.

Soils high in fertility can produce larger amounts of plant growth and, hence, larger amounts of organic matter to add to the soil. Even the roots and residue left on the soil after harvesting a heavy crop add organic matter.

4. Higher soil fertility increases crop yields on the more level fields, thus reducing the need for growing row crops on sloping fields where water erosion takes its heaviest toll. Sloping fields that erode easily can be kept in grass and trees.

By improving the fertility of soils, needed agricultural crops can be grown on fewer acres, thus releasing more land for livestock, forestry, wildlife, and recreation.

Most plants need about 16 chemical elements. Of these, 4 are usually in short supply and 1 or 2 are scarce enough to require some attention. The

4 major elements are calcium, nitrogen, phosphorus, and potassium. Some of the others such as zinc, iron, or magnesium, may be deficient in some special cases.

Nitrogen stimulates the growth of leaves and stems and gives the plant a dark green color. As already pointed out, nitrogen can be taken from the air by legumes. Nitrogen can also be added in several forms such as ammonium nitrate, urea, and ammonia.

Phosphorus is essential to the development of plant seeds as well as other parts of the plant. It is usually added in the form of superphosphate—a fertilizer made from ground rock phosphate treated with acids.

Potassium is needed by plants to grow strong stems. Potassium fertilizers are made from potash salts obtained from potash mines, and from other sources.

Ordinarily fertilizers are referred to as 0–45–0, 10–6–4, 4–16–8, and so on according to the percentages of total nitrogen (N), available phosphoric acid (P_2O_5), and water soluble potash (K_2O) they contain in that order. And so in the first case we have a fertilizer containing no nitrogen, 45 percent available phosphoric acid, and no potash. In the second case we have 10 percent nitrogen, 6 percent phosphoric acid, and 4 percent potassium oxide, commonly called potash.

Since very few soils contain the right balance of all the elements needed for any one plant, some kind of fertilizer is usually needed. A soil may be high in nitrogen and potassium but low in phosphorus. Crops' needs also differ. Since crop yields are limited by the element most deficient, the elements that are deficient should be added.

Soils can be tested to determine what elements they need. When the needed fertilizers are added, a good crop can be expected, if there is enough rainfall and other conditions are favorable.

XVII. Observe How Birds Help To Destroy Insects

Locate a nearby robin's nest. Then find a spot where you can watch it without disturbing the robins.

After you are sure the eggs have hatched, watch the nest for an hour at the same time each day and count the number of trips the parent birds make to the nest. Do this for several days and average the number of trips they make in an hour.

You can be fairly sure that on each trip they make the birds are carrying at least one insect of some kind. Actually, they may be carrying several.

After you have made the count for several days and have averaged the number of trips they make per hour, multiply this figure by the number of hours of daylight. This will give you an estimate of the total number of insects this pair of robins destroys in a day.

INTERPRETATION

Most forms of wildlife help farmers and ranchers produce more and better crops by checking insects, weeds, and other pests. Wildlife is equally helpful to the orchardist, gardener, and city dweller.

The number of beneficial forms of wildlife a well-managed farm supports is surprising. For example, on a 100-acre farm in the Eastern United States, we might find the following:

Several million beneficial insects such as ladybeetles, aphis lions, and syrphus flies which feed on plant lice; chalcid and tachinid flies which feed on many kinds of insects; and assassin bugs, robber flies, and nabids, which capture and feed on other insects.

More than 40 kinds of beneficial birds and about 450 individuals, of which about 80 would be in the fence rows, 180 in the woods, 90 in the pasture, 90 in the meadow, 10 in the small grain, and 5 in the corn. These include many small birds such as sparrows, warblers, and vireos.

More than a thousand beneficial small mammals, principally short-tailed shrews. About 40 percent of these would be in the meadow, 30 percent in the pasture, 20 percent in the woods, and the other 10 percent in the fence rows, grain, and corn.

The food habits of birds make them especially valuable to agriculture. Because birds have higher body temperatures, more rapid digestion, and greater energy than most other animals, they require more food. Nestling birds make extremely rapid growth, requiring huge amounts of food.

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A border planting of trees, shrubs, and legumes protects the edge of the field against erosion and makes good wildlife food and cover.

They usually consume as much or more than their own weight in soft-bodied insects every day.

Young robins have been observed to gain 8 times their original weight the first 8 days of their life.

Insect-eating birds must fill their stomachs 5 to 6 times daily because they digest their food so fast and because of the large amount of indigestible material in insects.

One young robin, weighing 3 ounces, consumed 165 cutworms weighing 5½ ounces in 1 day. If a 10-pound baby ate at the same rate he would eat 18⅓ pounds of food in a day.

Of course, birds cannot control insects completely, but they are of great value. By using soil- and water-conserving practices farmers and ranchers could probably double the population of helpful birds. Field and farmstead windbreaks, living fences, shrub buffers, grass waterways, and farm ponds are only a few of the many land use practices useful in attracting and increasing beneficial forms of wildlife.

Some birds are also valuable as enemies of mice, rats, gophers, and other destructive small animals.

Other animals that help keep a balanced living community on the farm are rabbits, squirrels, deer, muskrats, woodchucks, opossums, and raccoons. These animals are valuable for their meat or fur, too.

XVIII. Plant a Tree

This activity is best suited to springtime in the North and to fall in the South. It may be made a part of an Arbor Day observance.

Plan in advance the kind of trees you are going to plant and where they will be planted. Soil and moisture conditions will determine to a great extent the kind of trees to plant. How the trees will be used will also have a bearing on the kind of trees selected.

Check with local specialists about the best time to plant and the kinds of trees best suited to the soil and location.

In addition to the seedlings or transplants, you will need buckets for carrying the seedlings, water, grub hoes or mattocks, spades, and shovels or specially constructed dibbles or planting bars. The size of planting stock will help determine planting method and tools needed.

If the area is covered with grass sod, use the grub hoe to strip the sod away from a spot 12 to 18 inches square. If the ground is hard, dig it up and crumble the clods.

Carry the seedling trees in a 12- to 14-quart pail half filled with water, or in boxes containing wet moss or burlap to keep roots moist at all times.

1. Take only one tree at a time from the container and leave the roots exposed no longer than necessary.

2. Set the tree in the hole no deeper than it grew in the nursery.

3. Do not put pieces of sod or undecomposed trash in the hole where it will be in contact with the roots.

4. Tamp the soil thoroughly around the roots; do not leave any air pockets.

5. Water thoroughly.

You will need to water the tree frequently if the ground is dry.

Also, the young trees will need cultivation 1 or more years in many sections of the country to eliminate grass and weed competition for moisture. A straw or grass mulch spread 1 to 2 feet around the tree will, in areas of high rainfall, eliminate or reduce the need for cultivation. For information on the best way to plant and care for trees in your area, see your county agent, extension forester, or soil conservation technician.

INTERPRETATION

Forests have played a big part in building and maintaining our farms, cities, States, and Nation. As our young Nation grew, timber was needed in greater and greater quantities until much of the original woodlands were harvested.

Although we are now growing just about as

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Woodland like this with abundant undergrowth provides maximum protection for the soil and an excellent habitat for wildlife.

much saw-timber as is being cut, we are cutting more softwoods (fir, pine, spruce)—the kind we like and use most—than we are growing. It is the hardwoods (oak, yellow poplar, gum, birch, maple, ash) that make up the difference.

Enormous amounts of wood are needed in our day-to-day lives. For example, 65 acres of spruce trees of pulpwood size are needed to make the paper to print the Sunday edition of The New York Times.

More than 200 million cords of pulpwood were required to meet all needs from 1950 to 1956, inclusive, or an average of 37 million cords a year.

Another function of the forest—one of the most important—is to protect watersheds. The headwaters of nearly all the major rivers lie in forests. Good management of these forests is one way of protecting the source of water.

Forests are homes for many kinds of wildlife—deer, bear, elk, beaver, squirrels. Small woodlands are natural homes for such fur bearers as the skunk, opossum, mink, raccoon, fox, and weasel.

Three out of every 4 acres of our 485 million acres of commercial timberland is privately owned. Of this, 60 percent is in 4½ million farms or other small ownerships that have only 500 acres or less. The people of the United States own 180 million acres in national forests. If our Nation is to have a continuing timber supply, all owners must see that trees are properly managed and replaced as they are harvested.

To keep such a large acreage in continuous production requires enormous planting operations. If left alone long enough most forests would replant themselves. But man cannot afford to wait and has, therefore, learned how to do the planting himself.

Foresters estimate that about 50 million acres of timberland in the United States need planting if they are to become productive within a reasonable time. Additional millions of acres of poor farmland should be planted to trees.

Spacing of the trees is important. A spacing of 6 by 6 feet requires 1,210 trees an acre. Closer spacing requires more trees. If planted too thick, the trees either must be thinned later or allowed to thin themselves through crowding and stunting. But closely spaced trees cover the ground more completely during the early years after planting and stop erosion sooner. In a thick stand wider choice can be allowed in thinning; if some of the trees die the result is not so serious.

XIX. Trace the Origin of Things We Use

All you need for this activity is a pencil and paper. Or, if the club does it together, a portable blackboard and chalk.

As an activity for individuals, give the boys and girls a list of common items they use every day. Ask each one to write down where the items came from and the steps along the way.

As a club activity you can make a game with two sides competing. Select an item and let each group talk it over and see which can be first to trace the origin of the item.

The answers might go something like this:

Shoes—department store—shoe factory—tannery (where leather is made from cowhides)—packing plant (where animals are slaughtered)—stockyard (where farmers bring their animals for sale)—farm (where the cow is produced)—corn, oats, hay, and other feeds which the cow eats (grown on the farm)—*soil* where these crops are grown.

Candy bar—store or vending machine—candy factory—

Now break down into various ingredients: chocolate—chocolate bean—plantation in Brazil—cocoa tree—*soil*. Sugar—sugar factory—plantation in Hawaii—sugarcane field—sugarcane—*soil*. Nuts—peanut distributor—field in Georgia—peanut plant—*soil*.

Try others such as nylon and rayon for articles of clothing and synthetic rubber for an eraser. This may require the use of the encyclopedia but will turn up some interesting information.

INTERPRETATION

Soil is one of our most useful natural resources. From the soil we get food, clothes, and materials for the houses we live in.

From gardens and truck farms we get vegetables. Fruit grown on trees and vines comes from orchards, groves, and vineyards. Wheat and corn for making flour and meal for our bread comes from planted field crops. Nuts and berries come from farms and forests.

Our animal food comes from the soil too. Cows eat grass, hay, silage, and grain to produce milk. Hens eat grain and other feeds to produce eggs. Beef, pork, lamb, poultry come from animals that eat plants or feeds that come from plants.

The fuel that warms our houses comes indirectly from the soil. Coal is made from plants that grew ages ago. Oil and gas also originated from the organic materials, possibly including the remains of animals. All of these things grew in the soil at one time or lived on things that grew in the soil.

Fish from the sea, rivers, and lakes live on plants. And these plants live on dissolved minerals that washed into the sea, rivers, and lakes from the soil.

Scientists have found that in the United States it now takes 2 to 3 acres of good land to grow the food and clothing for one person. (An acre is about the size of a football field.) Some land will produce more than other land, of course, but this is an average.

If you could live on potatoes or corn alone, you would need only two-thirds of an acre. But when you feed the corn to animals to produce meat, eggs, and milk, then about 3 acres are needed.

XX. How Many Uses for Wood Do You Know?

All you need is a pencil and paper for this activity.

Make a list of all the items used about your home or your farm that are made from wood and wood products.

INTERPRETATION

Wood is a universal material and no one has ever been able to make a satisfactory count of its many uses. The Forest Products Laboratory, a research institution of the United States Forest Service, at Madison, Wis., once undertook to make an official count of wood uses. When last announced, the number was more than 4,000 and the argument had only started over how general or how specific a use had to be to get on the list.

Just one well-known wood-cellulose plastic, including its conversion products, claims 25,000 uses—among them such different items as dolls' eyes and advertising signs. The use of wood fiber as the basis for such products is increasing every day.

We often hear the question: How much lumber is used in the United States during an average year? The answer is: About 36 *billion* board-feet. Visualize a boardwalk 40 feet wide and 1 inch thick; imagine the boardwalk extends from where you stand three-fourths of the way to the moon. That's 36 *billion* board-feet.

More than two-thirds of that amount goes into building construction—not only for shelter, but for protection, comfort, and beauty as well. The rest is used for all sorts of manufactured articles—boxes, furniture, matches, millwork, toys.

Another important use of wood is paper for printing our books, magazines, and newspapers. A high point in our culture came less than a century ago with the discovery that wood fiber could take the place of cotton or linen in paper manufacture. Today we use more than 20 million tons of paper and paperboard each year. Of this amount each person's annual share of all kinds of paper is about 300 pounds. When paper was made chiefly of rags, each person's annual share was less than 10 pounds.

Newsprint accounts for about a fourth of our paper use. The rest is in myriad forms—writing paper, fiberboards for shipping everything from soap to axheads; sanitary cartons for prunes, cereals, butter, ice cream; paper cups, plates, forks, and spoons; disposable napkins, towels, handkerchiefs; wrapping paper for groceries, meats, dry goods.

Scientists and engineers at the Forest Products Laboratory are carrying on a specialized research into the uses of wood. They are developing more efficient use of timber in large structures by improving joints and fastenings necessary in bridge, arched hall, and hanger construction.

We must also grow trees for soil and water conservation. There are millions of acres of land in the United States that are not suited to cultivation but that can grow trees. If this land were put into crops, the soil would wash away. The result would be floods, streams choked with silt, reservoirs filled with mud, crop failure caused by lack of irrigation water. Also mountain streams would dry up, springs would cease to flow, and many forms of wildlife that live in the forests would disappear.

Steep land, rocky land, shallow soil, some wetland, some dryland, and many other land and soil conditions require the growing of trees. If we had no use for trees other than to protect land not suited to grass or cultivated crops, that would be enough.

XXI. Make a Conservation Corner

Select a township hall, a rural schoolroom, a home workshop, garage, or other place suitable for a conservation corner. This can be a club project with all 4–H'ers participating. This "corner" can be a place to exhibit many things that relate to the wise use of soil, water, grassland, woodland, wildlife, and mineral resources.

You will need a long table. Here are some things that you can collect and keep on the table:

Different kinds of soil—silt, clay, sand. Put them in small glass jars and label them.

Different kinds of rocks from which soil is made—limestone, sandstone, shale, marble, granite, and as many others as you can find. Label each. A good way to keep rocks is to embed them in a 1-inch layer of plaster of paris poured into a cardboard box. After the plaster hardens, remove the box.

Samples of different kinds of fertilizers. Keep in small glass jars and label.

Seeds of various crops that have soil conservation uses such as grasses, clovers, alfalfa. Label each.

Leaves, bark, twigs, and fruit of trees, shrubs, and vines that grow in your locality. Learn how to collect leaves and to press and mount them for display.

To make live things more alive and dead things "live," make your displays and collections tell a story. Collecting leaves, insects, and rocks is much more interesting if the leaves are organized into smaller, more significant displays of leaf types, and if the rock exhibits show how mountains are formed, what kind of soil they make, and what stones are used for building materials.

A label on an object or exhibit can capture interest, create curiosity, or make the reader think. The labels should be short, informal, and chatty. Make new labels occasionally to point out new facts of interest.

There may not be room for all the displays to be shown at once. But changing the scene is good and is more interesting anyway.

Set aside a shelf labeled "What is it?" Put unidentified finds here until someone identifies them. You can also put objects here that you want to draw to the 4–H boys' and girls' attention. As a special event put a number of objects on the shelf and give points for identification.

Make a conservation scrapbook by collecting pictures from newspapers, magazines, and other sources showing erosion and how it can be controlled. Relate soil and water conservation to plants, birds, and animals.

Make your scrapbook tell a story by organizing the pictures. For example, group the pictures so they show the kinds of erosion and the control measures used—terraces, contouring, grass, trees, farm ponds, and others. Collect pictures of birds and other wildlife that benefited in the change from an eroded to a well-managed farm.

Have a bulletin board and keep it interesting and attractive with pictures and articles on conservation from newspapers and magazines. Have a special section where 4-H'ers can report observations, such as birds, first spring flower, and others.

INTERPRETATION

The collection of materials for a conservation corner can be a vital, absorbing part of the conservation study. It can be made to show how soil, water, plants, and animals make up the living community.

Make the program a *doing* one. For example, boys and girls are much more interested in conservation when they are experimenting with seed germination and plant growth than they are in merely staring at objects laid in a row. Let the 4-H'ers build the conservation corner; let them run it.

Keep the conservation corner neat and give the specimens easily read labels. Change the corner to fit the seasons. Let the boys and girls help plan these changes.

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A 4-H Club Conservation Corner with bulletin board, visual aids, reading references, study specimens, and other club assembled things of interest stimulates a continuing interest in resource conservation.

XXII. Make a Model of a Conservation Farm or Ranch

Building a model of a conservation farm or ranch is an excellent culminating activity following a yearlong study of soil and water conservation. Such an activity provides 4-H'ers with first-hand knowledge of the various soil and water conservation measures and their flood-control features.

A model is the kind of activity in which all the boys and girls can participate. It should be

planned in detail under your guidance as leader. Decide what construction materials are needed, what soil and water conservation measures are to be applied, and how structures such as dams, terraces, bridges, fences, and buildings are to be modeled.

In making plans for this project consider the sources of outside information and assistance. Where can you find out what the local soil-erosion problems are and what conservation measures are in use? What visual aids and references are available? The county agent, Soil Conservation Service workers, vocational agriculture teachers, and conservation farmers and ranchers can be helpful.

The model can be a replica of the general terrain of the community in which club members live. Or you can select a farm or ranch that the club can study firsthand. Let the boys and girls see the erosion problems, then build a model showing the land as it should be used.

Models are usually built of fiber insulation board, papier mache, plaster of paris, or a salt-flour mixture on a sturdy base. One good method is to use pieces of thick fiberboard cut to match the outlines of the different contours of the land. The pieces are stacked in the order of succeeding elevations and glued together. The edges of the layers are then filed off with a wood rasp to make the slopes smooth and even.

If you want to make a model of an actual farm or ranch, your first step is to get a contour map of it. You can see your county agent, Soil Conservation Service worker, or county ACP office for sample maps of local farms. They can also give you help about reproducing the contours to scale on the model. If the terrain is flat you may need to exaggerate the steepness 2 or 3 times.

Make a base for the model from 1-inch lumber the size and shape of the farm. An 80-acre farm could be 2 feet by 4 feet. The first layer of insulation board should be the same size as the base.

Then cut the succeeding layers according to the contour lines and glue them together. You may be able to save material and reduce the weight of the model by having the layers overlap only a little so that the inside is hollow.

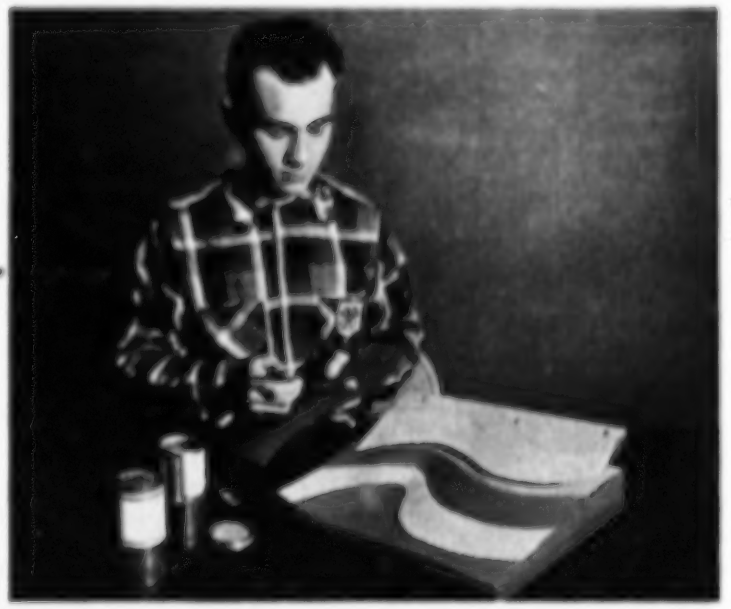
Plastic crack filler or papier mache may be useful during the final shaping. You may want to make some minor cuts and fills for roads, gullies, and other physical features.

As the first step in decorating the model, paint it with glue. While the glue is still tacky, sprinkle screened sand over it. This surface has a texture that will make it look like fields and pastures when painted suitable colors.

In deciding on the scale for the other items on the model, it is a good idea to start with the buildings. They need not be the same scale as the land; usually they can be somewhat larger. But other items such as fences, machinery, and livestock should be in scale with the buildings.

Buildings—Cut buildings from balsa or other softwood. You can do some carving but windows and doors can be painted in.

Fences—Drive dark nails or pins for fence posts and cut them off at a suitable height. For barbed wire, use fine wire fastened by a loop around each post. For woven wire cut strips of screen and push them into the modeling material; fasten with airplane glue.



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Painting a take-apart fiber-insulation board model of a strip-cropped field. When assembled, three pegs glued into the wooden base hold the contour layers in place.

Clover, alfalfa, and grass—The best way to simulate these crops is to paint the areas and sprinkle sawdust of appropriate colors over them. Sawdust coming from different kinds of machines, such as sanders, saws, chippers, and jointers, has different textures. The texture can be altered by screening. Coarse-textured sawdust is best for crops like alfalfa and clover; fine sawdust would be best for grass. Color the sawdust with a mixture of about one-fourth paint and three-fourths turpentine. Pour this over the sawdust and then spread it out to dry.

Bare soil—Fine sawdust, or the modeling material itself will give about the right texture if painted the right color.

Terraces—Loosely twisted heavy cord or small rope can be glued to the model. The areas above and below the cord or rope can be filled with crack filler shaped to give the form desired.

Corn—You can represent young corn by gluing strips of stiff burlap vertically in rows. After the glue has set, pull out the horizontal threads. Then split and curl the remaining vertical threads.

Shrubs—Cut sections from colored sponge and glue them in place. You can make isolated trees in the same way, but to represent a woodlot treat the whole area as a mass, using colored sponge.

Models of farms can also be made with papier mache. On a sturdy base make the shape of the farm you want by bending and shaping chicken wire. Then cover it with layers of paper dipped in paste, until you have the right amount for strength and form. Add the buildings, fences, and crops as explained above.

For younger boys and girls, don't overlook the sandbox. It offers a good opportunity to make a less elaborate model. Even with sand, it is best to copy an actual farm even though you will need to exaggerate the topography.

INTERPRETATION

If the farm or ranch model can be based on local land use problems and conservation needs, it will be most effective in helping children relate conservation to their own home and community welfare. Leaders in cities can relate wise use of soil and water to the everyday lives of urban club members by pointing out that food, lumber, wool, cotton, and other necessities come from the soil.

Your model farm can represent the conservation plan on the farm you are studying.

The successful conservation farmer follows a plan that was designed for his particular farm much the same way a tailor cuts and fits a suit to a particular man.

The first step in preparing this conservation plan is to find a good use for each acre on the farm. The physical characteristics of the land, in combination with the climate, limit how the land can be used safely.

No two acres of land are alike. The differences include variations in slope, soil depth, inherent productivity, stickiness, wetness, texture, amount of erosion, and many other features.

Some soils may be so shallow that cultivated crops will not yield enough for profit. This kind of soil is naturally best suited to grass or trees.

Some soils are sticky when wet and form hard clods when dry. Such soils are hard to farm and may take more work to prepare for seeding and cultivating. They let water in slowly and give it up to plants slowly. This characteristic may determine what the use should be.

How much soil has been lost by erosion has a lot to do with how land can be used safely. Severely eroded slopes will need maximum plant-cover protection. Grass and trees or shrubs for wildlife are usually the best use here, although some eroded land can be reclaimed for cultivated crops if the soil is deep enough and if the slope is not too steep.

Some land slopes so much that any cultivation of the soil will result in serious erosion in spite of all the farmer can do to protect it with mechanical measures. Even just a little too much grazing or too heavy cutting of timber will have bad effects. Steep slopes will be more profitable to the farmer in the long run if used for grass or trees.

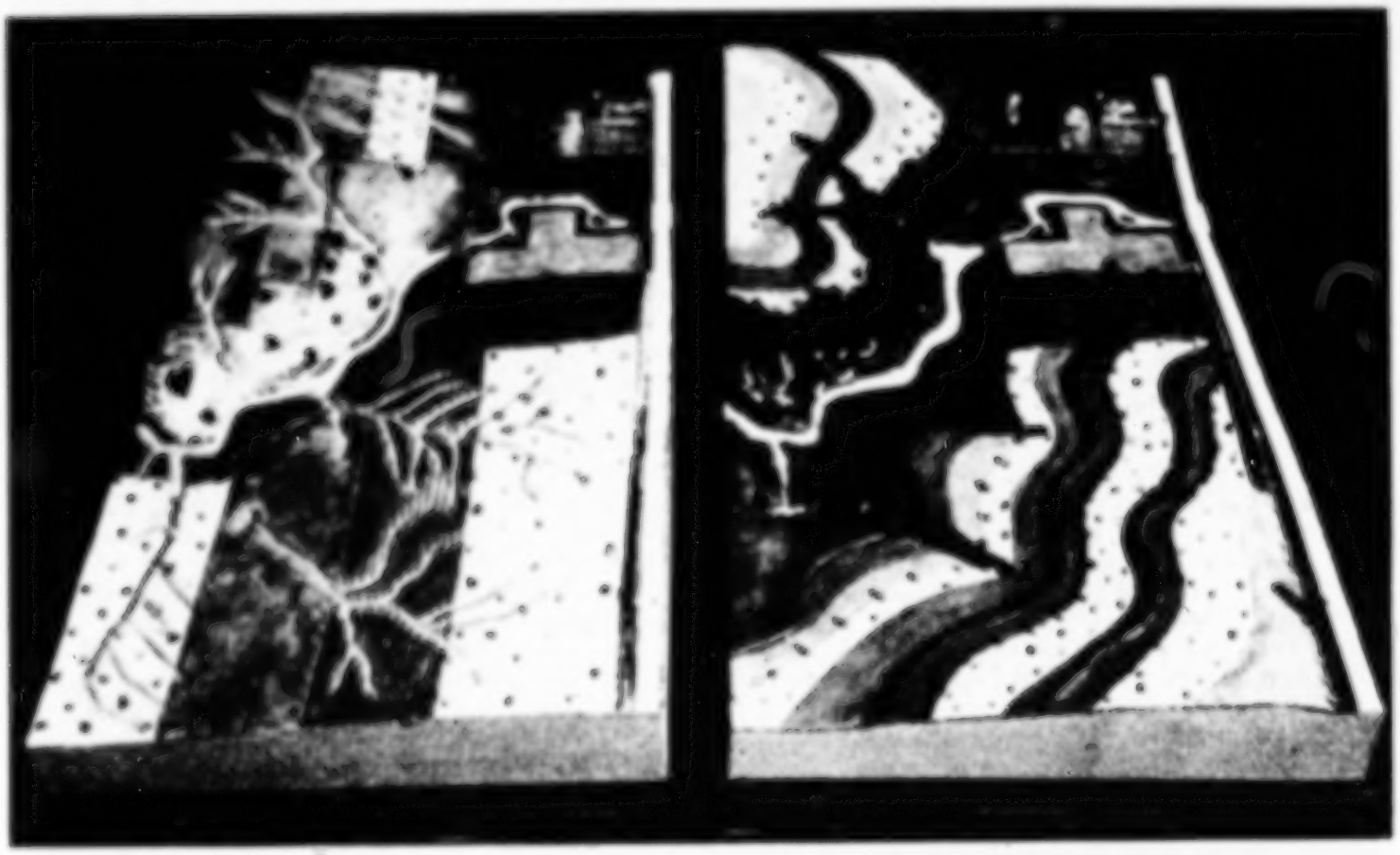
Gentle slopes, provided the soil is satisfactory in other ways, can be safely cultivated and used for crops like corn, cotton, and truck crops.

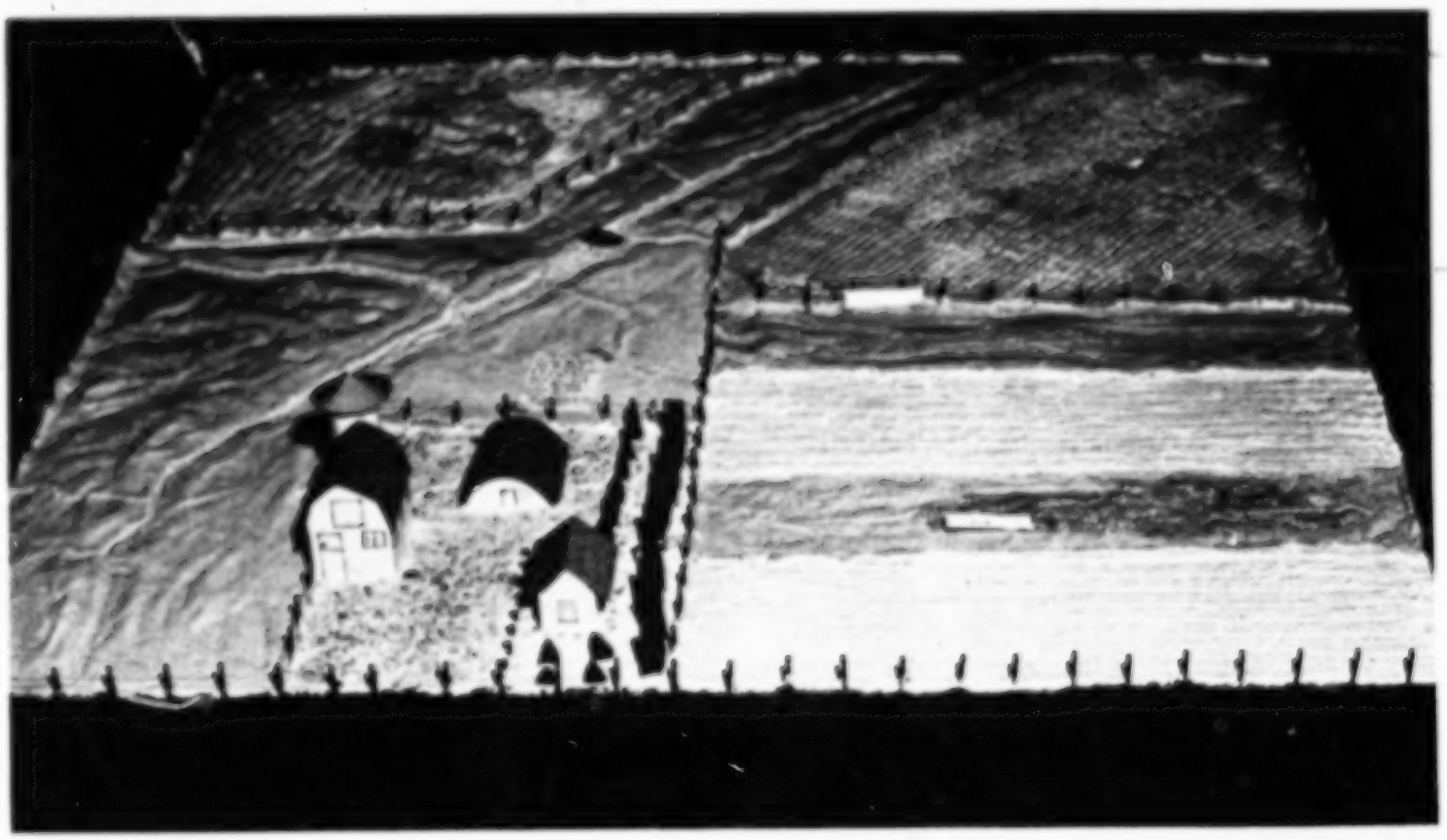
Level land that is well drained, does not overflow, has deep soil, and has no physical impediments like outcropping rock makes the best land for growing cultivated crops. Such land can be worked frequently without serious erosion hazard. Even this land needs good management to keep it productive.

After a careful study of the land and soil characteristics the farmer makes a plan to use each part of his farm within its capability as imposed by nature. This plan becomes the farmer's blueprint for his farming operations. It includes a field arrangement that puts each acre of land to work at a safe use. The field arrangement takes into consideration convenience of work for the farmer. It provides for separating cropland from grassland and from woodland. Some wildlife may be separated but all the land on the farm will be used by wildlife in some way.

After the farmer plans for the safe use of each acre of land he then plans the necessary supporting conservation practices like crop rotations, terraces, grass waterways, stripcropping, contour farming, pasture rotation, and woodland protection.

Such planning as this makes a soil conservation plan for a farm—a plan that fits the farm because it was made according to the physical nature of the land and a plan that suits the farmer's needs and abilities.





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Building a model of a conservation farm or ranch is an excellent culminating activity following a yearlong study of soil and water conservation. Such an activity provides 4–H'ers with first-hand knowledge of the various soil and water conservation measures and their flood-control features. Models are usually built of fiber insulation board, a salt-flour mixture, papier mache (above), or plaster of paris (below).

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